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THE HUMAN BODY

BY
ARTHUR KEITH, M.D., LL.D.

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PREFACE

This little book treats of the history of the human body rather than of its structure and mechanism. It reflects the opinions current among the more progressive anatomists of the present time. The author has relied to a large extent on the well-known works cited in the bibliography at the end, but it is only fair to the reader to mention the fact that many of the statements are founded on unpublished researches made by the author. The last chapter sums up the story of man's origin, and the reader, especially if unfamiliar with the geological divisions of time, may find it profitable to refer to this chapter when the first two or three have been read.

A. Keith.

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THE HUMAN BODY

CHAPTER I

HOW THE HUMAN BODY IS STUDIED

In all the medical schools of London a notice is posted over the door leading to the dissecting room forbidding strangers to enter. I propose, however, to push the door open and ask the reader to accompany me within, for, if we are to understand the human body, it is essential that we should see the students at work. If we enter in the right spirit—with a desire to learn something of the structure of man's wonderful body with our own eyes—there is nothing in the room which need repel or offend us. The room is lofty, well-lighted and clean; the students in their white coats are grouped round tables on which lie the embalmed bodies of men and women who have run the race of life—often, alas! with but ill fortune. The students are dissecting systematically, each with his text-book placed beside him for consultation and guidance, and with the instruments of dissection in his hands. The human body is to be the subject of their life's work; if they are to recognize and treat its illnesses and injuries they must know each part as familiarly as the pianist knows the notes of the keyboard. We propose to watch them at work. Each student is at his allotted part, and if we observe them in turn we shall, in an hour or less, obtain an idea of the main tissues and structures which enter into the composition of the human body.

By good fortune a dissection is in progress in front of the wrist, which displays, amongst other structures, the radial artery at which the physician feels the pulse and counts the rate of the heart's beat. The skin here is loose and thin, and as the student turns it aside in flaps he uses his knife to free it from the white subcutaneous tissue which binds it down to the deeper parts. He looks at his own wrist and sees why the skin here is loose; as he bends his wrist the skin is thrown into folds; when he extends it, the skin in front of the wrist is stretched; unless it were loosely bound down it would be impossible to move the wrist joint freely. On the palm the skin is different; it is thick and bound firmly by dense subcutaneous tissue to the underlying parts; there would be no firmness of grasp unless the skin of the palm were thick and closely bound down. As the student turns back the skin from the front of the wrist he searches in the loose tissue under it for the nerves which supply the skin with the power of feeling and for small veins which carry the used or venous blood back to the heart. He squeezes the blood backwards in these vessels; they swell out here and there into little knobs owing to the presence of pockets or valves which permit the blood to flow only in one direction, namely, towards the heart. It was the study of the arrangement of these valves, nearly three centuries ago now, which led Harvey to the discovery of the circulation. Beneath the skin and subcutaneous tissue there is another covering which has to be cut through before the sinews or tendons in front of the wrist are exposed to view. This third wrapping—the deep fascia the student will call it—is membranous and strong and keeps the tendons in place; workmen often find it necessary to add additional support by means of a wrist-strap. The tendons are glistening almost white; eight of them go to the fingers (two to each); one goes to the thumb and two act on the bones of the wrist or carpus. Just above the wrist joint the tendons have attached to them the muscles which flex the fingers and the wrist. They look so simple in the dead body; yet one has but to watch the fingers and wrists of the pianist or of the typist to see how quick and complicated they can be in life. As the student traces the tendons into the palm of the hand he sees them become infolded within a loose sac with its interior lined by a smooth lubricated surface. This synovial sac is an example of the perfect manner in which the human machine is made; a self-oiling mechanism is provided at each point of friction. From overwork or injury fluid may collect in this sac and weaken the power of the workman's wrist.

Lying side by side with the sinews at the wrist there is another cord, somewhat like them in appearance, but very different in nature. It is the median nerve. Our friend the dissector has already seen a patient in the wards of the hospital with a jagged wound at the wrist which has injured the nerve. In that case he noticed that the thumb, fore, middle and part of the ring fingers had lost their usual sense of feeling, and that some of the small muscles of the thumb had no longer the power of movement. For our benefit he traces the nerve upwards in the forearm, arm, through the armpit until it reaches the root of the neck, where it is seen to be formed by five pairs of nerve roots which issue from the spinal cord. In the median nerve we see one of the paths which unite the brain and hand; messages pass by it from the hand which the brain interprets as heat or cold, rough or smooth, sharp or blunt; other messages pass outwards from the brain to start or stop the muscles of the forearm or fingers. The student pays particular attention to the radial artery; on the wrist, just above the root of the thumb, he finds the vessel resting on the lower end of the radius. He places his finger over the artery and observes how easily he can press it against the bone. In life we feel the artery suddenly expand and then subside with each beat of the heart; with a finger on the pulse the physician knows how the heart is working.

We propose to observe the dissector as he traces the radial artery to the heart. Below the bend of the elbow it is seen to issue from the main vessel of the upper arm—the brachial; the brachial in turn is found to be a continuation of the great artery of the armpit—the axillary. From the armpit the great arterial channel is followed across the root of the neck through the upper opening of the chest or thorax until it joins the aorta—the great vessel which springs from the left ventricle of the heart.

It must not be thought that the artery at the wrist is merely an elastic-walled pipe which expands passively as the ventricle discharges its load of blood; it is much more than that. When the student places a very thin section of the artery under the microscope for our particular benefit, we see that it has an exceedingly smooth lining, in order that the blood may flow with a minimum of friction; outside the lining there is seen an inner coat which contains many elastic fibres; then another coat made up of small contractile or muscular fibres. These muscular fibres regulate the size of the artery; they give or yield with each beat of the heart, and then contract, thus assisting the heart to force the blood onwards to nourish the tissues of the hand. The artery we have just seen under the microscope had been continuously expanding and contracting for over seventy years at the rate of seventy or eighty times a minute. No elastic tube yet invented by man could have done that. We note, however, that it has suffered the changes which overtake our arteries when they have been at work for forty years or even less; the elastic tissue and the muscle fibres are clogged with lime-salts; the elasticity of youth is gone. Hence as we grow older we cannot make the violent "spurts" of our youth.

Before leaving the dissection we have been surveying it will be well to see one of those marvellously contrived structures known as a joint. The wrist joint is still hidden by the tendons; even when these are cut through the interior of the joint is not yet visible; it is enclosed by stout bands of tissue or ligaments which become tight when the joint is over-bent. They prevent dislocation of the joint; indeed, so strong are those of the wrist joint that when we stumble forwards, or fall on the outstretched hand, it is the bones and not the ligaments which are apt to give way. When the ligaments are cut through, the articulating or jointed surfaces of the bones are seen. They are covered by an exceedingly smooth coating of white cartilage. Here, again, there is a self-lubricating mechanism which reduces friction at the joint to a minimum. In those individuals, however, who have the misfortune to suffer from rheumatism the self-lubricating mechanism has failed, the cartilaginous covering has become dry and worn away, and instead of a joint which works smoothly and silently there is one which is rough and creaks like a gate swinging on a rusty hinge.

We have surveyed the anatomy at the wrist in some detail and with a very distinct purpose. At every part of the limbs—upper and lower—we see the same arrangement of parts as at the wrist. There is first a covering of skin, then a layer of subcutaneous tissue, which unites the skin loosely to the third wrapping—the deep fascia. Within the sleeve of deep fascia are packed the muscles which move the limbs, the nerves which control the muscles and supply sensation to the parts; the great arteries which carry the nourishing blood from the left ventricle of the heart, and the great veins which return the used blood to the right ventricle—the pump of the lungs. When the fleshy or perishable parts are removed by dissection or by the corruption which so soon overtakes the soft parts after death, only the bones or skeleton remain to represent what was at one time a marvellous living machine.

We now propose to transfer our attention for a short time to two students who are uncovering the parts in front of the neck between the chin and breastbone or sternum. The windpipe has already been exposed, and is seen issuing from the voice-box or larynx below the chin to disappear at the upper opening of the chest on its way to the lungs. On each side of the windpipe the carotid arteries are found passing upwards to supply the head and brain with blood; close by them are the jugular veins carrying the venous blood in an opposite direction. Here we have an opportunity given us of seeing a peculiar feature of man's structure. Just above the larynx the carotid artery divides into two branches, an external one which nourishes the face, and an internal one which supplies the brain with blood. Man has a large brain and a relatively small face, hence in him the internal branch is the larger. In all other animals the external is much the larger, because the face is massive while the brain is small. It has been suggested that our brains are large because of the calibre of our internal carotid arteries; that statement we do not believe any more than the word of the waggoner who assures us that it is the dray which pulls the horse. Our object, however, in examining the anatomy of the neck is to see that curious structure or gland known as the thyroid body. It is made up of two parts or lobes, one on each side of the larynx and upper part of the windpipe; the lobes are united together by a part which crosses in front of the windpipe. Most glands in the body, such as the salivary and liver, have ducts or channels by which is discharged the substances they secrete, but there is no duct connected with the thyroid. The secretion which it forms is discharged directly into the blood stream and hence it is called a ductless gland or a gland of internal secretion. In recent years we have come to recognize that the secretion of the thyroid body is of the greatest importance. In children who suffer from disease of this gland we see that the growth of their bones is delayed or ceases, their skin becomes pasty, puffy and ill-nourished, and what is more serious their brains do not develop properly, and they become cretins or idiots. In some parts of this country—especially in Derbyshire—the thyroid is apt to become enlarged, forming a goitre and giving rise to the condition popularly known as "Derbyshire neck." There are other ductless glands, such as the pituitary body which lies enclosed within the skull and below the brain, and the suprarenal bodies which are situated in the abdomen above the kidneys. Our sense of well-being, our capacity for work and for pleasure, the nourishment and growth of our bony frames depend to a very great extent on the manner in which these small, insignificant-looking ductless glands perform their proper functions.

Our time with the students in the dissecting room has almost expired; there remains only a moment to glance at a dissection which is exposing the important organs which are enclosed within the thorax and abdomen. Part of the front wall of these cavities has been removed. Within the thorax we see the heart enclosed within its fibrous sac—the pericardium. Two great arteries issue from its upper part—the pulmonary artery to convey the impure blood from the right ventricle to the lungs, and the aorta from the left ventricle to nourish the body with pure blood. Two great veins enter the right side of the heart—the upper and lower venæ cavæ; they bring back the impure blood gathered from the various parts of the body. The pulmonary veins convey the pure blood from the lungs to the left side of the heart. Within the thoracic cavity are the two lungs, one on each side of the heart. They are mottled and dark with soot, showing that their owner had breathed the air of those who live in large cities.

At the moment we have chosen to view the students at work two of them are examining that wonderful partition—the diaphragm—which separates the chamber containing the heart and lungs from the lower or abdominal cavity in which the organs concerned with digestion are placed. Thanks to the discovery of Röntgen these students have a decided advantage over their predecessors of fifteen years ago ; they can see the diaphragm, which is mainly composed of muscle, actually at work in your body or mine. As we take a breath the domes of the diaphragm are seen to descend, enlarging the cavity of the thorax, and we see the lungs become clearer as they expand and are filled with air. We can also see the dark shadow of the liver descending below the right dome of the diaphragm and the transparency that marks the stomach pushed downwards under the left dome. As we allow our breath to escape we see the domes of the diaphragm again ascend, and if we place our hand on our bodies as we breathe we shall observe that, as the diaphragm ascends, the muscles which enclose the abdomen are at work, pressing the viscera and the diaphragm upwards and thus returning the parts to a proper position for taking another breath. All the muscles which we now see connected with the walls of the cavities of the thorax and abdomen are concerned in respiration. At the moment of birth they begin to work and keep on unceasingly all through the years of life until death brings to a final stop one of the most wonderful mechanisms of the human body. We have not the time now to look at the nerves and nerve centres which control the muscles of respiration and keep them at work both when we sleep and when we wake.

There are structures connected with digestion which we might examine, but we must postpone their consideration until another opportunity. It may have occurred, however, to the onlooker that, since we can trans-illuminate the human body, it is no longer necessary to dissect it. Dissection is still necessary, for we cannot interpret correctly what is seen when the body is lighted up under X-rays unless we already possess an extremely accurate knowledge of the arrangement of parts as they are displayed in the human body after death.

Our cursory visit to the dissecting room has not been in vain if the reader has realized how complex the structure of the human body really is, and how necessary it is that those who have to cure its disorders should try to understand the intricacy of its mechanism. We have seen, however—and this is of more importance for our present purpose—the manner in which our knowledge of the human body is obtained. What one generation of anatomists has learned is written in books and thus handed on. For more than three centuries men have studied the structure of the human body, and yet to-day there is still much, very much, which we do not understand, but we live and work in the hope that our knowledge will continue to increase.

CHAPTER II

THE HUMAN BRAIN

We propose to visit the dissecting room again, this time with the definite purpose of seeing the human brain—that wonderful organ which has lifted mankind to so high an estate. We shall see a structure which, to all outward appearance, might have been that of a great man—one of those who have written our plays, our novels, our philosophies, or who have conquered the world by force, by invention or by sweet persuasion. Here, on the threshold of the medical school, a confession must be made of our ignorance: no one, however skilled he may be, can tell, from merely surveying the brain, whether its owner was a clever man or a foolish one. The day may come when an examination of the brain will reveal its capacities, but we have not yet reached that position. Having made this confession we make our way to a small anatomical theatre in the school, and take a seat with the students on the benches which rise tier on tier, almost to the roof. Before us stands a white-coated anatomist; he is to give a demonstration on the brain, showing it to us in its natural position within the body. The scalp, in the subject of demonstration, is folded back, and the cap of the skull removed. Before the brain can be seen, a thick membrane (dura mater), which lines the interior of the skull or cranial cavity, has also to be turned aside, but this is easily done, for the brain is merely in contact with it. The chief part of the brain is thus exposed—the part known as the cerebrum. We note that it occupies that region of the skull which lies above the ear-holes, and that it extends forwards to occupy the forehead above the orbits and backwards to fill the projecting occiput above the root of the neck. The brain is wrapped in a semi-transparent membrane through which we see a rich supply of blood vessels on its folded or convoluted surface. Between the folds and convolutions there are depressions and fissures.

The cerebrum is divided into two hemispheres, right and left, a fact which we could not have guessed from our inner consciousness, for we seem to think as if with one organ. The anatomist presses the right and left halves slightly apart and shows a wide white bridge of nerve fibres (the corpus callosum) joining them. He further informs us of another mystery—the right hemisphere presides over the left half of the body while the left hemisphere is connected with the right side. He narrates a case, to illustrate the crossed relationship of brain and body, which he had seen some days previously. The case was that of a working-man, the subject of fits, in each of which he fell down with the fingers of the *right* hand moving convulsively. The surgeon marked out a small area on the *left* side of the patient's head, and operating there found a small tumour pressing on the underlying part of the brain. Its removal effected a cure. We see then why the surgeon operated on the *left* hemisphere when it was the *right* hand which was affected, but to realize how he was guided to the exact spot for operation we must look at the surface of the brain exposed before us. The surface is thrown into convolutions separated from each other by depressions. The longer and deeper depressions are known as fissures. We notice that the main one—the fissure of Sylvius—begins on that part of the brain which lies just behind the eye and beneath the temple and passes backwards and upwards to end some distance above the position of the tip of the ear (Fig. 1). The fissure of Sylvius separates the frontal and parietal lobes of the brain, situated above the fissure, from the temporal lobe, which is situated below it. Towards the posterior end of the brain the temporal and parietal lobes join with another important lobe—the occipital. Crossing the surface of the hemisphere from above downwards and separating the frontal from the parietal lobe is a fissure of the utmost importance to us. It is

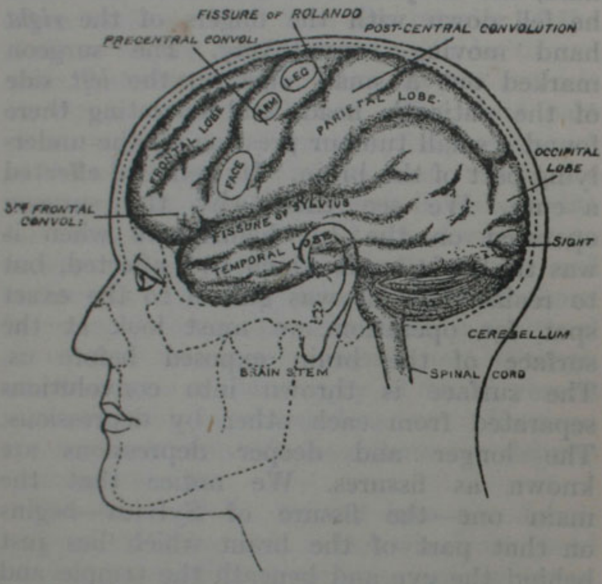

Fig. 1.—The main divisions of the Brain, showing some of the functional centres.

the fissure of Rolando or central fissure (Fig. 1). On the convolution in front of the central fissure—the precentral convolution—is situated the area which regulates the movement of the arm. It was the knowledge of this fact which guided the surgeon. The central fissure is also seen on the brains of monkeys; in the man-like apes or anthropoids the fissure is very human-like. Some forty years ago it was discovered that when the cortex or surface layer of the convolution in front of the central fissure was stimulated electrically, the unconscious ape performed certain definite movements. If the upper part of the pre-central convolution was thus called into action certain movements of the opposite lower limb resulted; if the middle part, motions in the opposite upper limb; if of the lower part, movements of the opposite side of the face, lips and tongue could be called forth. Further, it was discovered that the parts of the convolution behind the central fissure were connected with sensations arising in corresponding parts of the body. There are two inferences which we draw from these facts; (i) that the human brain must be formed on the same type or plan as that of the ape, for the medical man is able to apply, in diagnosing diseases of the brain, the knowledge he has obtained by experiments on the ape; (ii) that each part of the brain has its own peculiar function. Only the convolutions immediately in front of the central fissure give rise to movements; when other parts are stimulated there is no muscular response. Thus it is, that at the present time there are large parts of the brain whose function is unknown—parts which we believe serve for memory, judgment and imagination.

We must, however, keep our eyes on the demonstrator and watch him as he proceeds to show us how the cerebral hemispheres are connected with the body. When they are raised from the floor or base of the skull we see a great stem—the brain stem—issuing from them; in size it is about the thickness of a baby's wrist. When this is cut through the cerebrum can be lifted away, and we note the remarkable fact that only one pair of nerves end directly in the hemispheres, namely, the olfactory or nerves of smell. The optic nerves from the eye are now visible; they encircle and seem to end on the back of the brain stem. Impressions arising in the eye—the sensations caused by light—pass first to the brain-stem, but from their termination other nerve paths are provided which can be traced into the cerebral hemisphere towards the posterior or occipital lobes. The occipital cortex in which the paths end are known to subserve the functions of sight; blindness is produced when they are destroyed by disease. When the cerebral hemispheres are removed from the head it is seen that their posterior parts did not rest on the base of the skull as the frontal and temporal lobes did, but on a fibrous partition. When the anatomist removes the partition we see beneath it a minor compartment which contains the cerebellum and the continuation of the stem of the brain. The cerebellum is implanted on the upper or posterior aspect of the stem, and we note that it is only about a ninth part of the cerebrum in point of size, and that its substance is not convoluted, but is thrown into leaflets. Until a few years ago the wildest guesses were made regarding the function of the cerebellum. Phrenologists place the centre for amativeness on that part of the head which overlies it. Its exact function is not known, but we are certain it is not the seat of our consciousness, nor of our higher faculties; there is evidence now to show that it is an automatic mechanism for regulating and co-ordinating our muscles when they are in action.

Before the cerebellum and the stem of the brain can be lifted out and shown to us, the anatomist finds it necessary to divide the continuation of the latter as it escapes from the skull to enter the canal of the backbone, where it changes its name and is known as the spinal cord. Even if we did not see the stem of the brain and the spinal cord in their natural position in the body we could tell where the one ended and the other began. In the spinal cord the nerves (31 pairs of them) arise from its sides by two roots, one posterior, the other anterior in position. In the stem of the brain they arise irregularly, some of them corresponding to the line of origin of the posterior roots of the spinal nerves, some to the anterior roots, while others arise in an intermediate line. In 1811, exactly a century ago, a young Scotsman of the name of Charles Bell made a very great discovery relating to the manner in which the nerves arise. While waiting in London for patients, he opened a private school in Soho for teaching medical students the anatomy of the body. He wished to explain to them why the brain was divided into cerebrum, cerebellum, and stem, and why the nerves arose in one manner from the stem and in another manner from the spinal cord. His difficulty was due to the fact that in his day anatomists supposed the brain to be the seat of mind, will, and consciousness. The brain they thought worked as a whole and could despatch or receive a message by any nerve. Bell came to the conclusion that this supposition must be wrong; there must be an explanation for the division of the brain into parts and for the complex manner in which nerves arose. Two reflections put him on the track of his great discovery. Bell did not know what we have seen, that stimulation of part of the brain gave rise to muscular movements, but he did know that there was a nerve track which descended from the cerebrum to the spinal cord through the brain-stem. He guessed it was by this nerve path that the will exercised its dominion over muscles, and he noted that it descended in the front part of the cord—the part from which the anterior roots arise. He concluded that the anterior roots must also be for carrying messages to muscles. He stimulated the anterior root in a living animal and found the muscles supplied from it were thrown into action. He therefore supposed the anterior part of the spinal cord and stem of the brain must be for producing movements and all the nerves which arise from their anterior parts must be *motor* nerves. We have already seen that the nerves of sight ended on the posterior part of the stem of the brain. Bell inferred from this fact that the posterior parts of the stem and of the spinal cord must be connected with sensation, for the optic nerve is purely for conveying impressions from the eye to the brain. He inferred that the posterior roots of the spinal nerves which end in the posterior part of the cord must be for conveying impressions from the body to the brain. They are the sensory roots. He stimulated them in living animals, no movements in the muscles were produced. Bell thus made the discovery not only that the roots of a spinal nerve were different in function, but the more important one that the anterior part of the great nerve stem was for motion and that the posterior parts were connected with sensation. We have seen that some nerves arise from the brain-stem neither in line with the posterior nor with the anterior roots but from an intermediate line. Bell inferred they must be peculiar in function because they were peculiar in their origin. Time has proved that in this he was also right; seventy years later Dr. Gaskell, of Cambridge, found that these nerves (ninth, tenth and eleventh pairs of cranial nerves) are different in nature. They supply the heart, lungs and other viscera. They are visceral nerves; over these the will has no control.

Having thus shown us the chief parts of man's nervous system—the cerebrum, cerebellum, brain-stem, spinal cord and nerves, our friend the anatomist returns to the part he commenced with—the cerebral hemisphere —in order that we may see some of the peculiar features of the human brain. We wish especially to see that part of the brain which is connected with speech, for of all man's gifts that of language is the most remarkable. A clever parrot or a mynah bird may have a voice and a power of imitation, but they cannot be said to have the power to receive and convey thought; only a human brain has that power. We have already been shown that the convolution of the brain which controls the movements of the lips and tongue is situated in front of the lower end of the central fissure (Fig. 1, p. 24). We might have guessed that the convolution which serves in speech—the inferior frontal convolution —would be close by. It is a little way further forwards. Its exact position in the head is indicated when a finger is placed on the left temple, about an inch behind the upper margin of the orbit. The inferior frontal convolution is situated on the anterior margin of the deepest depression or fissure of the human brain—the Sylvian fissure, named after Sylvius, who taught anatomy in Paris during the seventeenth century. It was Broca, working in Paris in the latter half of the nineteenth century, who discovered that the inferior frontal convolution of the left side was connected with speech. The deep fissure of Sylvius, as we have seen, passes backwards and upwards on the side of the cerebral hemisphere; below it is the temporal lobe of the brain in the upper part of which the centre for hearing is situated (Fig. 1). There is a connexion or pathway between the hearing and speech centres, for if we are deaf we must necessarily be dumb; the child listens as it imitates its mother's voice.

The chief features of the human nervous system having been thus demonstrated to us, we take our leave of the students and of the anatomical theatre, but before making our exit from the medical school we may turn aside for a minute to examine some specimens in its museum. In an out-of-the-way corner we come across the cast of a cleanly shaven head, mapped out into sixty little plots, according to the instructions of Dr. Gall, who founded the study of phrenology at the beginning of the nineteenth century. We notice that he has placed the organ of hope on that part of the head which lies over the convolution connected with the movements of the body; the organ of amativeness is situated on the region of the cerebellum, while that of constructiveness is placed over the inferior frontal convolution. We see that there is no correspondence between Gall's doctrine of phrenology and our modern knowledge of the brain. Yet to this extent Gall was right; the various parts of the brain have their own particular function. The day may come when by looking at the brain or even at the skull which encloses it, we shall be able to tell the capabilities of a child or man, but we have not yet reached that point. Even should that day come it is improbable that the phrenologist will be able to tell character as well as the ordinary man who merely observes the expression of the face, the tone of the words, the actions and the deeds of the person under observation. It is true that a wide and high forehead, indicating great development of the frontal lobes of the brain does incline us to anticipate capacity in a man, yet we are often mistaken; we have known men of unquestioned ability with low and narrow foreheads. Even the size of the brain is not a safe indication. In most cases one can form a fairly accurate opinion of the size of the brain from the dimensions of the head. In the average man the skull and the soft parts covering it do not vary in thickness so much as to upset our calculations as to its size or volume. It is true that the chambers or ventricles within the brain may be dilated and thus give the brain a false size, but that is not a common condition. The size of the brain depends to a certain extent on the bulk of the body; tall men on the average have larger brains than small men, just as a Newfoundland dog has a bigger brain than a fox-terrier. The increase of brain which is directly due to increase in size of body gives no increase of brain power; hence tall and bulky men are not necessarily more able than small and short men. Thus, although we cannot argue that because a man has a big brain he is a man of great capacity, yet the fact remains that many of the world's most famous men had large heads and big brains. In the average Englishman the brain weighs 1,360 grammes[1] (forty-eight ounces); in Cromwell it is said to have been 2,231 grammes and in Byron 2,238 grammes. In Gambetta, the French statesman, it weighed only 1,294 grammes. Still, if size of brain is not a certain index of capacity, it must be taken into account; Broca found when he compared the brains of a group of eminent men with those of men of ordinary ability that the average eminent man had a brain eighty grammes above the ordinary. When the sexes are compared it

[1] An ounce is equal to 28·3 grammes.

is found that the brain in man is 130 grammes more than in woman on the average. Woman's smaller brain is due chiefly to her smaller body, for we have seen that size of body has a direct influence on the size of brain. Whatever view may be held as to the equality of the sexes, woman cannot be disqualified on account of the size of her brain. Therefore we must admit that size is not a valuable index of capacity, and the same must be admitted as regards shape. Certain American Indian tribes distort their heads and brains by the application of bandages in infancy and yet their mental capacity does not seem to be in any way affected. We see, too, that the human head varies much in shape; in some it is narrow and long; in others broad and short; in others short and high or long and low. The long and narrow head is common in England; the broad and short head in Germany and France, and yet, as far as we know, the brain which is within the short and wide skull has no advantage over the one within the narrow and long head. Thus all attempts to read character and mental capacity by examining the outward form of the head or of the brain have so far been in vain.

Before leaving the museum of the medical school there is another group of specimens we ought to examine, namely, those which show how the brain and spinal cord are formed during the early stages in the development of the human body. The early stages of the human embryo are represented by accurate models in which the various parts are greatly magnified. During the early part of the third week of development the brain and spinal cord are seen as part of the covering or epidermis on the upper surface of the embryo; the area of epidermis which forms the future nerve system is oblong in shape. In a model showing a slightly older stage the oblong area has become depressed to form a trough; presently the edges of the trough come together, the margins of the embryonic skin closing over the nerve trough, which now forms a tube enclosed in the back or dorsal side of the embryo. The front or head part of the tube forms the brain; the hinder part forms the spinal cord. By the third month two outgrowths are evolved from the brain part of the tube; one of these forms the cerebrum; the other the cerebellum. To one who is unfamiliar with the facts of embryology it must seem a preposterous thing to suppose that our brains can have been evolved from a modification of an area of skin. Still these are the facts of development; how otherwise can they be explained except by supposing our brains are areas of the body-covering which have been modified? Children are frequently born, as may be seen from specimens in medical museums, where the nerve plate has never been folded in but remains spread out on the surface and merging at its edges into the skin of the back and of the head. In such cases we see in the human body a hark-back to a condition that must have been represented in very low forms of animal life at an early stage of the world's history. That marvellous structure, the human brain, is the product of millions of years; its history begins with life itself, millions upon millions of years ago.

When the reader leaves that strange place, a medical school, to which we have tried to introduce him, and emerges on the street to see men busy and energetic in all the affairs of life he will find it difficult to believe that there is aught in common between man's brain and that of any other animal created. As he walks along, however, he will notice how men differ; a man here and there has a brain weight of 2,000 grammes, and perhaps a corresponding ability; another has perhaps only 1000 grammes; in seeking for man's allies it is not the highest but the lowest human types we must use as a starting-point. Amongst Australian aborigines it is not uncommon to find a woman with a brain weight of 1000 grammes or even less. When it is added that the gorilla, the chimpanzee, the orang, have brain weights that vary from 300 to 500 grammes he will conclude that there is a vast difference in even weight between man and the great anthropoids. There is a great gulf, but it is not a fixed one. A fossil form of man, Pithecanthropus it is named, had a brain which in point of size is intermediate between that of modern man and the gorilla's. There is an equally great gap between the great anthropoids—the gorilla, chimpanzee and orang—and the small anthropoids—the gibbons. If instead of comparing grown up men and anthropoids we compare them both at birth the difference is less. At birth the human brain weighs about 300 grammes, about one-fifth of the weight it ultimately reaches; the brains of the anthropoids are only slightly less, 200 to 300 grammes. Thus, while man's brain is only about one-fifth of its adult weight at birth, that of the anthropoid is already two-thirds. Man has to be sheltered and educated; the anthropoid baby has to face the realities of life soon after birth. When we survey man and the anthropoids at birth, the brain difference does not seem an insuperable barrier between them. Indeed, in all mammals the brain grows much more rapidly than the rest of the body; this is especially the case in man. By the end of the second year the human brain has reached two-thirds of its adult size, it has then reached the same relative degree of development that the anthropoid has reached at birth. There is another peculiar fact about the growth of the human brain; it has reached its maximum size by the twentieth year. After the twentieth year, or even a little before, it begins to lose in weight and goes on losing until old age, when the decrease becomes more rapid. As Professor Karl Pearson has said, man's prime is not a period, it is merely a point of time.

CHAPTER III

MAN'S PLACE AMONGST ANIMALS

MOST men are not aware of the toil and trouble zoologists have taken to name and number the animals of the earth and to arrange them in groups according to the manner in which their bodies are made. We know the commoner animals as they come before us, but do not trouble about the relationship of one beast to another. As regards man, he seems to us so very different to all the common animal forms that we cannot believe him to be related to them at all, but prefer to regard him as standing isolated and alone, as a being of a peculiar order. When, however, we begin to study his body and compare it, organ by organ, with that of other animals, we see that his isolation disappears, and that it is the thick veil of civilization in which he has so completely hidden himself that misleads us regarding his true position in the animal kingdom. The reader will see that I am preparing his mind for the kind of evidence to be produced in this chapter—evidence as to "Man's place in Nature," as Huxley happily named it in his celebrated book published in 1863. We propose to visit an institution in which Huxley loved to work and to lecture, namely, the Museum of the Royal College of Surgeons of England, situated right in the heart of London on the south side of Lincoln's Inn Fields. The museum has a history; its foundation was laid in the latter half of the eighteenth century by the great surgeon, John Hunter, one of the very greatest men this country has ever produced. He was centuries ahead of his time, and hence he is not yet properly appreciated The hours he could steal from work and sleep he devoted to the study of all forms of life; but instead of describing on paper what he saw and discovered, he left the actual specimens themselves—all duly preserved, to tell their own stories to future generations. Since his day men like Sir Richard Owen and Sir William Flower have added to and tended Hunter's priceless collection, so that here we can study the evidence afforded by man's body better than anywhere else in the world. Hunter's invariable method was to commence with the simplest and lowest forms of life and work gradually through the more complex which led on to the highest—man himself. As we enter the museum it soon becomes evident that it will answer our present purpose best to reverse Hunter's order, and in each instance commence with the human form.

As we pass through the first and second rooms of the museum we see the skulls and skeletons of all races of mankind, European, Asiatic, American, African and Australian, in case after case, but only the practised eye picks out the peculiar features of each race; as far as the evidence of the skeleton goes mankind appears to be a very uniform species. It is in the third room that the first real break is encountered, where the human series ends and the anthropoid skeletons begin. The skeleton of the gorilla is not at all human in appearance, the great crests on the skull, the massive jaws and face, the long stout arms, the short lower limbs with a thumb-like great toe, seem to assure us that even the most man-like of apes is a long way off from man himself. Yet when we look more closely we see that every bone of man's body is present in the gorilla, they occupy exactly the same place in the skeleton; each bone shows the same leading features; the differences relate merely to proportion, size and detail. When we look at the skull of the young gorilla, before the massive, brute-like crests have appeared, the human resemblance is more marked. In the skulls of the adult chimpanzee, these cranial ridges, which are developed to give attachment to the great muscles of mastication, are much smaller than in the gorilla. In the orang they are intermediate in size. They are much larger in the male than in the female anthropoids. The gorilla and chimpanzee are from Africa; the orang from Borneo and Sumatra. It is thus in the forests of the tropical parts of the earth that we find the animals which most nearly resemble man in structure. There are various races of gorillas, chimpanzees and orangs, just as there are various races of mankind, each race being a native of its own peculiar district or country.

Passing from the cases containing the skulls and skeletons of the three great anthropoids to those in which the small anthropoids—the gibbons—are contained, we note another break in the series, quite as marked as the one between man and the great anthropoids. The head and body are much smaller; there are the same bones set together in the same order but the proportions are different. There are numerous races of gibbons scattered through the forests of the far East, from China in the north to Java in the south. In the series of cases which follow, containing first the skeletons of the many kinds of monkeys of the Old World and then those of the New World, we are made aware of the impossibility of representing animals in their right relationship by grouping them one after another in a single file. To be right, there ought to be a double or a triple file here, one for the Old World monkeys, another for those of America, and an intermediate one for the gibbons. Between the gibbons and the monkeys there is a wider gulf than any we have so far seen, yet we cannot well say the one is higher than the other. In certain features we see that the gibbons are related to the Old-World monkeys, in others to those of the New World; we believe that there must be extinct ancestral gibbons which, did we know them, would show us that these three forms of primates have all arisen from a common stock at a long past period of the world's history. It is the American monkeys which interest us most, because amongst them we find quite small and low forms, such as the marmoset, which takes us a little way towards the kind of animals shown in the museum cases following those containing the monkeys—the lemurs. Between the marmosets and the lemurs, however, is a much wider gap than we have yet tried to cross; we realize that we are passing from one order of animals to another, from the primates to the primatoids. Beyond this point in the animal scale we do not intend to pass. If at first we had seen the skeleton of man placed side by side with that of the tiny marmoset we would have denied that there could be any possibility of a common origin for these two, but when we pass from the one to the other through a series which, while showing many breaks, leads us step by step from the one to the other, we begin to see that the miracle of man's primate origin is not so impossible as it appears at first. We note, too, that the links which we miss most lie, not between man and his nearest allies, but between the gibbon and the monkeys grouped near it.

Leaving the rooms in which the skeletons are shown we make our way to another in which the teeth of all kinds of animals are displayed, in order that we may ascertain what guidance they can give us regarding man's place in the animal scale. In the first place we examine the dentitions of young children; in the upper, as in the lower jaw, we observe that twenty teeth are already erupted; of the twenty, eight are cutting or incisor teeth; four are canine or eye-teeth; eight are grinding or molar teeth. The teeth just enumerated form the milk set. Embedded in the bone beneath the gum we see the permanent teeth in process of formation; there are sixteen in each jaw. Of the thirty-two permanent teeth, twenty take the place of the milk teeth, the eight milk molars being replaced by teeth of a different type—the premolars. The permanent molars, twelve in number, are added to the milk set. To make room for them a growth takes place in the jaws which leads to the marked changes we see taking place in the face during childhood and adolescence. The four first molar teeth erupt about the fifth year, the four second, about the fourteenth year; the four third molars or wisdom teeth are most irregular in their appearance in us Europeans; they may cut at any time between the twentieth and the fortieth year, and in a considerable number of people they never erupt at all.

In the anthropoids the third molars always come into use; in the males they erupt with or even before the canine teeth. The canine teeth of the male anthropoids are large and need a considerable number of months to reach their full growth after they have pierced the gum. While the permanent teeth of anthropoids are all in place by the fourteenth year, the human dentition, even in primitive races of mankind, is not complete until the twentieth year, and as we have just seen, in European and civilized races the period of completion may be delayed until quite late in life. In primitive races, as was also the case in ancient Europeans, the wisdom teeth never fail to erupt. It is only in European or civilized races that there is a marked tendency to a suppression of the last or most posterior of the molar teeth. There is also a tendency for an arrest of the growth of the jaws in the same races. Civilization appears to be exercising a deteriorating influence on human teeth and jaws. It seems as if our wisdom teeth had become unnecessary, and that in this matter our dental constitution is out of keeping with our present-day needs.

On the other hand, one does occasionally see in the skulls of native Australians and of other native races, an extra or fourth molar added. A supernumerary molar is frequently seen in the dentitions of orangs and gorillas. These extra molars do not appear to be reversions to a former condition, but are really of the nature of a progressive adaptation.

As we pass from the human specimens to those illustrating the anthropoid dentitions, noting as we go the large teeth and strong jaws of native races—such as the Australian and Oceanic aborigines—we are at once impressed with the massive jaws of man's nearest allies. They project forwards to form a decided muzzle. In the infant anthropoids, however, we note the same twenty milk teeth, arranged as in the maxillæ of the human child; in the adolescent anthropoids we see the same number of permanent teeth coming into position as in human jaws. The wisdom teeth appear as soon as or even before the canine teeth. It is the canine teeth which characterize the anthropoid dentition; instead of occupying a place in the regular series they project above their neighbours as conical tusks. They are much larger in the males than in the females; they are especially small in the female chimpanzees; the canines of the milk set are much less prominent than the canines of the permanent set. We observe, further, that the cusps of the crowns, and the fangs of the roots of the teeth are arranged on the same plan as n man; the differences are chiefly those of detail. In the small anthropoid or gibbon the number of teeth in each set is the same as in the large anthropoids; the gibbon's teeth are much smaller, with the exception of the canine teeth, which are especially long and sharp in both males and females.

When, however, we come to examine the teeth in monkeys we see many points of difference. In the Old World monkeys the number of teeth in both the permanent and milk dentitions remains the same as in man, but the cusps of the molar teeth are arranged on a totally different principle. In the New World monkeys the cusps of the teeth are arranged as in man and the anthropoids, but the number of teeth is different. They have twelve instead of eight premolar teeth. We have reason to believe that primates had originally sixteen premolar teeth; the American monkeys have lost four, while man, the anthropoids and Old World monkeys have lost eight of the original number. Occasionally we see an extra premolar appear in the human dentition. If we were to fix man's position among animals by the evidence of his teeth alone, we should place him on one side of the great anthropoids, and the gibbon, at about the same distance, on the other side of them, but all three included in the same group. In another group of equal value to the one just mentioned must be placed the Old World monkeys, while a third would contain the American monkeys.

Having surveyed the evidence afforded by the teeth displayed in the odontological room we move to the galleries of the museum, where we shall find Hunter at his very best. The preparations are grouped to show how the various functions of the animal body are carried out—the organs for locomotion, the organs of circulation, of respiration, for reproduction and for the purposes of sense and nerve action. In every series the preparations begin with organs selected from the lowest forms of life; each series is arranged to show the various steps which lead on from the lowest to the highest. The particular specimens we wish to examine at present are those which digest the food and absorb nutrition—the stomach, the bowel, and the various glands connected with digestion such as the liver and pancreas. We see at once that these organs are similar in shape and arrangement in man, the great anthropoids, and in the gibbon, but when we pass down the series to the organs which represent the monkeys of the Old and of the New World, we see that the arrangement of the viscera in the abdomen is different, and even the shapes of the organs are altered. It is true that in the liver of the gorilla we note deep indentations or fissures which are absent from this organ in other anthropoids and in man; we see in this a minor but puzzling peculiarity of the gorilla's anatomy. In all these higher primate forms we note on the right side of the abdomen, just above the groin, that the small intestine ends in a capacious cæcum, the name given to the dilated commencement of the great bowel. At the closed and lower end of the cæcum, in the anthropoid, as in man, is attached a narrow tube—the notorious appendix vermiformis. It terminates blindly below and hangs freely within the abdomen lying more or less behind the cæcum, into which its upper end opens. Vermiform or worm-like is not an unhappy term, for in life the appendix may be seen to slowly twist and turn as its muscular coat passes into action during digestion. It varies in size according to the age of the individual and the state of digestion. In the gorilla it is of the thickness of the small finger, but twice as long; in man it is shorter and smaller, but in him its shape and size are subject to the utmost variation after puberty. Unfortunately, we do not know the uses of the appendix, but on many occasions the writer has noted in the anthropoids and in children that the contents of the cæcum pass freely into it. In the gibbon it is quite usual to find within it seeds of fruit, as big as cherry stones, during active and normal digestion. So far we have never known of appendicitis occurring in anthropoids living in a state of nature, but they do become liable to this disease when kept in captivity and fed on a human diet. In monkeys the cæcum terminates below in a blunt conical point, which represents the appendix, but no real narrow worm-like appendix is present. Yet it is very possible that at one time an appendix may have been present in monkeys, for in lemurs, which represent an older type than the true primates, a true appendix is found. On the other hand, it is possible that the highest group of primates and the lemurs have acquired an appendix independently. It is not necessary to make a further survey of the organs of digestion; we see that if we were to classify animals according to the abdominal viscera, we should have to place man, the great anthropoids and the small anthropoids or gibbons in a single group. Even to the detail of possessing an appendix vermiformis they are the same.

In another gallery we may examine the evolution of the nerve system from the lowest to the highest. At the end of the series are placed the massive and complex brains of various races of mankind; much further down the series we note the small and simple brain of the marmoset. In shape it is not unlike the brain of the human fœtus at the end of the third month of development. We note that the brains of the great anthropoids in size and complexity are intermediate to the comparatively simple brain of the gibbon on the one hand and the human brain on the other. One point rather impresses us. As far as the skeleton was concerned we saw that the gibbon and the monkey were widely separated, but when we come to examine their brains the difference between them appears to be much less in degree. Yet in every point in which the brain of the gibbon departs from that of the monkey it approaches the cerebral forms of the great anthropoids.

We might examine each system of the human body in turn, but it is unnecessary, for the anatomical evidence to be thus obtained would but bear out what we have already gathered. We see that man is a member of that group of mammals we have named the higher primates. He is one of the three families included in that group. The central family is represented by the great anthropoids; man on the one side and the gibbon on the other represent the two other families. All three families we believe to have arisen from a common ancestral stock, but while the gibbon has clung to the ancestral form, man has progressively and aberrantly evolved to his present position.

The great anthropoids have been steered in a middle course, and will without doubt at no distant date be extinguished when European civilization reaches their jungle homes. Then will there be a wide gap between man and his nearest living allies.

Of late years we have obtained evidence of another character which throws a strange light on the close relationship which exists between man and the great anthropoids. We have been in the habit of thinking that many diseases were peculiar to man, and that no other animal could be infected with them. Such, for example, was believed to be the case in syphilis. If an ordinary monkey is infected with this disease, no real inoculation takes place; at the most only a passing disturbance is manifested. The chimpanzee and orang can be really infected, as has been proved by those who are seeking to find a remedy for a disease which often produces most disastrous effects on man. The great anthropoids suffer only from the milder effects of the disease. Yet we have proof here that the constitutions of the great anthropoids have much in common with that of man, which is comprehensible if both are descendants of a common stock. Professor Grünbaum has shown that the anthropoids are also susceptible to other human infectious diseases. Bacteriologists have thrown a flood of light on the constitutional nature of animals.

In the course of their researches a method was discovered by which a minute quantity of the blood of any animal can be detected. The manner in which the test is carried out is highly technical. A special solution is prepared for testing the blood of each animal. We shall suppose that the solution prepared is for detecting human blood. When to this solution is added a fluid in which a stain of human blood has been dissolved a cloudiness appears in the solution, and a precipitate occurs in the test-tube. No other blood except human will give the full precipitate. If a solution of dog's blood is added there is no result. Professor Nuttall found, however, that a precipitate could be obtained with the blood of anthropoids—not so plentifully as is the case with human blood, but yet enough to show that in "blood relationship" man and the anthropoids stand very near together

CHAPTER IV

STATURE, PROPORTION, AND GROWTH

In this chapter we propose again to visit the Hunterian Museum in London to see those specimens which illustrate the growth and size of the human body. We wish especially to ascertain when and how man came to have a stature which varies between five and six feet, or to use the more convenient metric system, between 1,500 and 1,800 millimetres.

If we cross Waterloo Bridge in the throng of city workers hurrying to business, and thread our way to Lincoln's Inn Fields in the press of morning traffic, we have ample opportunity for seeing how varied the human body is in size, in shape, and in carriage. If we were to measure a thousand men as they pass by we should find that rather more than 500 of them had a stature between 5 ft. 5½ in. and 5 ft. 9½ in.; we may accept the height of the average man as 5 ft. 7½ in. (1,715 mm.). In the thousand men we should probably find ten who were under 5 ft. (1,525 mm.), and three or four who were over 6 ft. We observe, too, that the women are slighter in build and shorter in stature. On the average their stature falls 4½ in. below that of men ; more than half of them are between 5 ft. 1 in. and 5 ft. 5 in. The growth of women is not regulated by the same laws that hold good for men. If we could follow these busy people to their offices and watch them seated at their desks we should be surprised to see that some who were apparently tall as they walked along appear to be of average height when seated ; others who in the street seemed of short stature now appear to be of an average height. It is evident that stature depends on two distinct factors, the length of the lower limbs, and the length of the trunk or body. The sitting height gives us the height of the body. When a man or woman who are of the same height, sit down, it is usually the case that the woman appears the taller, because her body is proportionally longer than that of the man, while her lower limbs are relatively shorter.

Arriving at the museum we make our way to the various rooms which will provide us with evidence as to when mankind came by its present size of body. Our search lies first among the specimens which represent the bones of men who lived in Europe when its northern half, including the greater part of Britain, lay under ice. How long ago that may be cannot be accurately estimated, but most geologists are agreed that the bones we are now looking at belonged to men who lived 100,000 years ago, or even more. When we compare these bones of fossil men with our own we see that their owners were stouter made but not so tall as we are. The famous Neanderthal man, whose bones were discovered in 1857 at Neanderthal in Germany, stood about five feet four inches in height. Indeed all the examples which have been discovered of the Neanderthal type of man show us that ancient man was far from being the giant which fable and tradition have led us to expect. Indeed we know of no tall men in Europe until the glacial period was drawing to a close. The Cro-Magnon race then appears in France; many of the men of that race stood six feet high; but the opposite sex appear to have been only a little taller than modern women. The very earliest form of man yet discovered—the fossil man of Java, usually named Pithecanthropus—was about five feet six inches high. The evidence so far leads us to believe that our present stature and size of body are part of an ancient inheritance, one which has not been altered by the passage of hundreds of thousands of years.

We must approach the problem in another way, for we have not as yet discovered the ancestral human forms which are older than Pithecanthropus. When the skeleton of man is compared with those of the great anthropoid apes—the gorilla, chimpanzee and orang, it is at once seen that as regards size, all of these form a uniform group. The adult male chimpanzee is about the same weight as an average man—viz. from ten to eleven stones (sixty-three—seventy kilos). The adult male orang is heavier—about twelve to thirteen stones, while the adult male gorilla is about fourteen stones. The gibbons or small anthropoids weigh from fourteen to eighteen pounds, only about a tenth of the great anthropoids. Monkeys vary in weight from two to thirty pounds. In the standing posture, man's long lower extremities give him an advantage over the short-legged anthropoids; he stands nearly a head higher than they. But if we measure them in the seated posture man's superiority disappears. While his head and trunk measure about thirty-four inches, those of the chimpanzee reach to about thirty-five inches, the orang about thirty-seven inches, and the gorilla about thirty-nine inches. The head and trunk of the gibbon measure only about twenty inches, approximately the same as one would find in a boy of about two years of age. Now we know that great anthropoids were in existence at a period which predates the fossil man of Java; in the fossil beds of the North of India (Siwalik), which geologists regard as formed in the Pliocene period of the earth's history, bones of an anthropoid as big as the orang have been found. The very earliest of the large fossil anthropoids which have yet been discovered is the kind now named Dryopithecus. The bones of this anthropoid, which was smaller than the chimpanzee, but much larger than the gibbon, have been found in the strata of France and of Germany which geologists regard as formed in the Miocene period—the one which precedes the Pliocene. At a still earlier date in the Miocene period we know that anthropoids similar in form and size to the modern gibbons were in existence, but we do not yet know of any big form of primate which is older than the Miocene period. We have every reason to suppose that it was during the early part of that period—how many millions of years ago one does not dare to hazard a guess—that the large bodied primates were evolved. These large Miocene primates appear to be the stock from which the great anthropoids and man have descended. The size of our bodies then is an old inheritance—one which has come down to us through millions of years.

We return to that part of the museum where we can study the growth of the human skeleton. Before us there are arranged specimens, row upon row, showing the development of the bones of the child before birth. It will be better, however, to confine our attention to one bone, and we select the femur or thigh-bone, because by watching the manner in which it is formed and increased in length, a guide will be given us to the way in which we attain to our adult height. Up to the seventh week, when the human fœtus is less than an inch in length, the thigh-bone is formed of cartilage; there then appears in the cartilagenous shaft a centre of bone formation, and the cartilage is gradually replaced by bone until only its extremities remain as cartilage. At the end of the ninth month the child is born, being then about twenty inches long, and seven lbs. in weight. In the skeletons showing the condition just before birth, we see that a separate centre of bone formation has appeared in the cartilage at the lower end of the femur, in those showing the skeleton of the child some months after birth we note a centre has also appeared in the cartilaginous head at the upper end of the femur. Passing on to the skeletons which show the condition in the eighth year we see that the ends of the bones are represented by separate parts or epiphyses, each of which is fixed to the shaft by a plate of cartilage. These plates of cartilage which join the epiphyses to the shaft are seats of most active formation of bone; the new bone laid down at these lines causes the femur to increase in length. On the surface of the femur also new bone is being laid down and thus the thigh-bone increases in thickness. These lines of growth—epiphyseal lines they are called—keep open so long as growth in stature continues; when, however, they become closed growth in height is over. Hence in the skeletons of women who have died about the age of twenty, and in those of men at the age of twenty-four, we find that most of the growth lines are closed. There is, however, a considerable degree of variation as regards the date of closure, for we know some men who grew very little after their twentieth year, and others who kept on adding to their stature until they were twenty-six or even older.

What causes these lines of growth to close at a definite period of life and prevents them from ever again becoming opened is still a mystery. There are two celebrated skeletons in an adjoining case of this museum which throw some light on the circumstances which determine growth and stature. These two skeletons are placed side by side. One is that of Charles Byrne, who was exhibited in London as "O'Brian the Irish Giant" and died in 1783 at the age of twenty-two. The skeleton has a height of seven feet eight and two-fifths of an inch (2,358 mm.). It towers above the skeleton of Caroline Crachami, "the Sicilian dwarf," who was also exhibited in London and died at the age of nine. Her skeleton is little bigger than that of a newly born child; it is only twenty inches high, whereas, if growth had been normal, she should have measured about forty-eight inches at the age of nine. The giant on the other hand is twenty-four inches taller than the average man. If we could discover what caused arrest of development in the one, and over-development in the other, we should be in a fair way to solving the mystery of growth. Towards the end of the nineteenth century it was discovered that giants of the type of O'Brian were really the subjects of disease; in all of them the small pituitary gland, which lies in the base of the skull under the brain, is the seat of an overgrowth, often of a tumour. In some manner an increase or alteration of the secretion of the pituitary gland, which passes into the circulation, acts upon the growing lines of the bones and stimulates them so that the bones increase in length at a rapid rate, thus producing the condition known as giantism. The increased growth is apparently due to an ncrease in the amount of pituitary secretion. The muscles and other neighbouring parts are similarly affected and grow at a corresponding rate. We infer then that one of the circumstances which regulates growth is the secretion of the pituitary gland. It seems within the bounds of possibility that we may yet be able to add even a cubit to the stature if we should so wish. Near by is the skeleton of an unfortunate man who was the subject of a disease of the pituitary gland; the gland had become enormously enlarged during adult life and after the growing lines of the bones had become closed. A cast of his face shows how massive and ugly the face has become; lips are thickened; the ridges over the orbits form great bulging masses which overshadow the eyes; the nose and face are really gigantic. His hands and feet are enlarged and overgrown. The backbone, abnormally curved, is much longer than is usual, while the chest is huge and barrel-shaped. All these changes occurred slowly, after the man was fully grown, and completely changed his outward appearance and his nature. We suppose that if the growth lines had still been open when the disease set in he would have become of great stature. The man was the subject of a disease of growth which we name acromegaly, and which we believe to be due primarily to an enlargement or tumour of the pituitary gland. In all of these cases the pituitary is enlarged.

In the skeleton of little Caroline Crachami we see the result of an opposite disease, but its exact nature we do not yet know. Instead of being about forty-eight inches high as the skeleton of a child of nine should be, it is only twenty inches. The bones, too, have scarcely passed beyond the stage reached in the skeleton of a child at birth; there has been a complete arrest of growth. It is possible that the condition may result from a deficiency of secretion from the pituitary gland, but there are grounds for suspecting that another gland which supplies an internal secretion is also at fault—namely the thyroid, which we have already seen in the neck. Many of the dwarfs who have figured in history and in fable have suffered from the same disease as Crachami. The famous dwarf, Jeffrey Hudson, a favourite at the Court of Charles I., was one of these. Even as a young man he was no taller than Crachami, and was served up in a pie at the table of the Duke of Buckingham as a surprise for the Queen of Charles I., to whom he became an engaging and sharp-witted little page. At a later stage of his manhood growth set in and he became forty-two inches in height by his thirtieth year. We see then that growth may be delayed until a late period in life.

We have already noted the fact that men are as a rule four or five inches taller than women. In determining the greater stature of the male it is possible that the sexual organs may have a powerful influence. It is now known that sexual organs have not only the duty of renewing the race,—but have also, by a secretion thrown into the circulation, an influence on the nutrition, well-being and growth of the body. We have only to look at domesticated animals and note the difference between the ox and the bull to see how deep-rooted the influence of the genital glands can be in shaping the size and form of the body. If we study the growth of children it becomes very apparent that the sexual organs play a large part in regulating the rate of development. Between birth and the twentieth year there are two spurts of growth. The first takes place during the first and second year—until the child learns to walk; in that period the stature shoots up from twenty inches to thirty-three or thirty-four inches—at a rate of about seven inches a year. Thereafter the increase is at the rate of about two and a half inches yearly until the age of puberty approaches and then the second spurt occurs. In Great Britain girls grow more rapidly than boys between the ages of ten and fifteen, and for two or three years are actually taller than boys of their own age. They are more precocious in their growth than boys. The thirteenth year is the one of most rapid growth in girls, whereas in boys it is the sixteenth. Between his fourteenth and sixteenth year a boy usually shoots up about eight inches. We know that at these later periods of rapid growth in the two sexes, the sexual glands are also undergoing a maturing change in structure and function, and we have good reason to suppose that the extra growth is directly due to a secretion these are supplying to the circulation. We thus see that our stature and our bodily growth are determined or at least regulated by a series of glands which exert an influence through their secretions.

Our stature and growth also depend on food, exercise and fresh air; there can be no doubt of that. It is well known that boys of well-to-do people at good schools are taller, heavier, and stronger than boys of poor people in schools situated within the slums of big cities. How much of the difference is due to food and environment and how much is the result of heredity, it is difficult to say, for the better-off class in England is taller than the poorest class. Children naturally inherit stature as well as other features of their parents. The stature of English soldiers is 1,701 mm.[1]; Oxford undergraduates, however, are 1,726 mm.—an inch taller, and those measured were not fully grown. A group of Scotch soldiers measured 1,713 mm.; a group of Irish, 1,707, of Germans, 1,696, of Italians, 1,620 mm. and the soldier of the United States, 1,736 mm. The various races of European origin have a wonderfully uniform mean stature; 5 feet 6 inches may be accepted as the mean stature of the average European man; the mean in some countries, such as Italy, falls to nearly two inches below the mean, while in another, such as Scotland, it rises about that amount above the mean.

As we survey the skeletons of the various races of the world which have been collected in the Hunterian Museum, it becomes very apparent that it is amongst the negro and negroid races that the greatest fluctuation in stature is found. The late Dr. MacTier Pirrie,

[1] 1,700 mm. = 5 ft. 7 in. 1 in. = 25·4 mm.

who lost his life while investigating the negroes of the Sudan, found that the Dinkas, who live in the valley of the White Nile, had a mean stature of 1,801.6 mm.—a fraction under 5 feet 11 inches. The Dinkas are amongst the tallest races in the world. Their lower extremities are remarkably long, making up more than half their height. Where the Sudan merges in the watershed between the Nile and the Congo basins, a negroid tribe—the Akkas—represent one of the smallest if not actually the smallest race of mankind. The men stand about 4 ft. 6 in. high, the women about 4 ft. 2 in. Further south, within the Congo Free State, numerous pygmy races of negroes are found forming settlements and amongst negro tribes of average stature. Still further south, in the region of Cape Colony, another pygmy stock is found—the Bushman race. They are taller than the Akkas, the men measuring 4 ft. 9 in., the women 4 ft. 7¼ in. Various pygmy peoples are found scattered in the Far East—in the Andaman Islands, the Malay Peninsula, the Philippine Islands, and in New Guinea. These Eastern pygmies are also negroid races with various features in common with the African pygmies. At first sight it may seem somewhat remarkable that the tallest and the shortest races should be found in the great negro division of mankind. When, however, we remember that stature is regulated by the action of certain glands, it becomes apparent that if the normal action of these regulators of growth is unfixed a double result may be expected—the production of small races on the one hand by under-action and tall races on the other by over-action on the part of the glands. The variability of stature is a characteristic of negro tribes.

At one time the idea gained some support that long ago Europe was inhabited by a pygmy people and that it was from such a race that traditions of elves and fairies had arisen. The basis of this theory was the discovery of bones of people of small stature amongst the graves of a race who lived in Europe when well worked flints were used as cutting and fighting tools. Professor Kollmann, who discovered these bones, thought they indicated the existence of a race of small people, but we now know that these small people formed only a very small proportion of the population to which they belonged.

We have thus made a brief survey of our present knowledge relating to stature. We have seen there is no basis for the belief that we are descended from giants, nor is there any real ground for believing our ancestors were pygmies. Our present size of body appears to be an old character—one which we inherited in common with the great anthropoids. Further we see that our stature is regulated by the action of certain small glands, and that over-action or under-action on the part of these may produce great fluctuations in stature. Dwarfs and giants may arise as sports in any race of mankind. Amongst negro and negroid peoples we see an especial tendency for the production of tall races on the one hand and short or pygmy races on the other.

CHAPTER V

THE ERECT POSTURE

THERE is some reason to think that man, when he institutes comparison between his own structure and carriage with those of other animals, is rather prejudiced in his own favour. It is very apparent from his literature that he has come to regard his own body as the most perfect organization yet created, and not without reason, for he has proved himself the conquering and universal species. The feature of his body which he prizes most is its erect posture; in that he sees a distinctive mark of superiority, and yet were a visitor from an outside world to appear as an impartial judge it would be the anomaly of this character rather than its superiority which would impress him. The earliest vertebrates adapted for life on land trailed their horizontal bodies along the mud or marsh on four weak limbs. In birds the two fore limbs have been converted into wings for an easy and swift progression in the air, while the two hinder limbs, with the thighs bent under the body, have been reserved for locomotion on land or water.

In mammals generally, the four limbs have become adapted for rapid carriage of the body; in some they have become modified for swimming, in others for climbing. Amongst mammals there are two forms which carry their bodies in a really peculiar manner, these are the kangaroo and man. In both the hinder pair of extremities have become specialized for locomotion, but there is no real resemblance in their styles of progression nor in the manner in which the body is carried. In man only have the lower limbs been brought into a line with the body, so that thigh and trunk form a pillar perpendicular to the ground on which he treads. Our posture and manner of walking never strike us as in any way peculiar; we are rather proud of them, because they are characters which mark us off from all other animals. If, however, it had been one of the ordinary four-footed mammals which had been endowed with our powers of observation and criticism, it is much to be feared that those peculiar features which we are so proud of would have been the subject of joke or criticism.

How then has man come by his remarkable posture of to-day? Many who have written about this phase of man's evolution have not fully realized the difficulty of the problem. They have assumed that at a far past stage of the world's history a form of monkey had abandoned a climbing life in the forests and become adapted to a life on the open ground. In place of running on all fours, a form of ape, they suppose, was gradually evolved which waddled on its two lower limbs. These were bent towards the belly at the hips and flexed at the knees, while the upper extremities were used as crutches to assist its unsteady gait. Such a method of progression is adopted by anthropoid apes in a state of captivity. It is further supposed that the lower extremities became by degrees straightened out at the hips and knees, gradually gaining in strength until they were able to support the head and trunk erect. The manner in which the crawling infant learns to walk gives some support to this hypothesis.

The evolution of our posture is not nearly so simple a problem as those writers and thinkers have supposed. The changes implied are much greater than a mere modification of limbs and of backbone; such a change entails a complete revolution in the organization of the body. As an animal runs along on all fours its viscera are supported on the flat muscles which pass along the lower surface and sides of its body; turn such an animal up into a human posture and all the viscera tend to sag down to the lower part of the abdomen. With the evolution of the upright posture a new method had to be evolved for keeping the viscera in place. The mechanism of respiration must also be changed. Monkeys, like dogs and cats, have their chests flattened from side to side; when the animal stands or runs its chest is slung between its forelegs. When such an animal is turned upright and made to support itself thus, all the muscles of respiration are disturbed in their action and act with difficulty. Hence we find that the human chest is shaped quite differently to that of four-footed animals, and its chief muscles have undergone an alteration in their disposition. The human chest is flattened, not from side to side, but from before backwards. The automatic nervous mechanism which regulates the distribution of the blood in the body of a four-footed animal has to undergo a complete adjustment to serve the same purpose for an erect animal such as man. The backbone which in a four-footed horizontal animal forms an arch between the fore and hind limbs, in an upright one is not only altered as regards its curvature, but also in the length and the shape of its various segments. The musculature of the backbone has to be revolutionized. The head in a monkey, as in a dog, is so fixed to the body that the base of the skull continues the line of the backbone; in man the head is poised on the spine so that the base of the skull is almost at a right angle to it. Nay, the closer one studies the matter, the magnitude of the structural transformation required by a change of posture becomes more and more apparent. There is not a bone, muscle, joint or organ in the whole human body but must have undergone a change during the evolution of our posture.

Our present task then is to see what evidence can be produced as to how and when man came by his posture. Such evidence does not come to the man who sits in his study and reads books; it is to be found only in the jungles of the tropics, and in the rocks and strata, where there are found fossil remains of animals which lived in tropical forests when the earth was much younger than it is now. It was the writer's good fortune to spend some time in a part of the Malay Peninsula many years ago. The region was hot, moist, malarious, and thickly covered with forest and jungle, in which monkeys of several kinds abounded. In the course of a morning's walk many families or troops might be encountered. As they scurried off, springing noisily from branch to branch, without ever coming to the ground, it soon became apparent that although each kind of monkey or ape had its own peculiar mode of making its way along branches, and springing from tree to tree, the gibbon or small anthropoid, which differed very little from other apes in size, was altogether peculiar in its gait. While the ordinary monkey ran along on all fours with its body parallel to the branch, using its hinder extremities as the chief means of gaining impetus for springing from tree to tree, the gibbon moved deftly along the larger branches on its legs, with body erect, and with its long arms stretched above its head to seize in passing the overhanging twigs for support. When seeking to escape it used its long and powerful arms as the chief means of progression. It was marvellous to see how it could swing itself from branch to branch and from tree to tree, often bounding thus across an interval of 40 or 50 feet. The ordinary monkeys were horizontal in posture of the body but the gibbon was upright. Later, when investigating the anatomy of the animals native to the jungle to ascertain whether or not they suffered from the effects of malaria, the writer had his attention arrested by the remarkable manner in which the gibbon and ordinary monkey differed in structure of body. In the gibbon the viscera of the abdomen were fixed and arranged much as in man; the muscles of the belly wall had the disposition seen in man; the thorax was flattened from back to front; the spinal column had the chief features seen in man's skeleton, with the exception that in the loins the column was straight instead of being curved forward as in the human body. As regards the features just enumerated the monkey resembled the dog rather than the gibbon. There, then, is a most important fact —a certain stage in the evolution in the upright posture has been attained in the gibbon. The gibbon is an ape with a body adapted for an upright posture, amidst arboreal surroundings.

The reader may well ask, "What has the upright posture in the gibbon to do with man's posture?" In answering that question a number of considerations must be kept in mind. The first and most important is the fact that the gibbon occupies a position in the animal scale between the great anthropoids—the gorilla, chimpanzee or orang, and the common monkeys of the New World and of the Old. It stands between the higher and the lower. Secondly, we know that the erect posture was attained by gibbons at a very remote period, for in the lower Miocene strata of the earth a form of gibbon, not unlike the present type, is known from its fossil remains. It is very probable that a type of ape similar to the gibbon was evolved at the beginning of the Miocene period, or even before that period began. That is certainly many millions of years ago. We know nothing of the early stages of the evolution of the upright posture in the gibbon, but we can realize that it implied a gradual and complete alteration in its structure and in its method of locomotion.

In the great anthropoids we recognize the same posture as in the gibbon. They are adapted for an upright posture on the trees. Men who have studied the attitude and gait of those animals in confinement have been misled by watching them waddling across the floor of their cage, using their long arms as crutches. They are different animals when at home in tropical forests. They all hold their bodies approximately upright, but differ materially in their methods of locomotion. The orang, like the gibbon, has extremely long arms, which it uses much more than its legs, in swinging itself from branch to branch and from tree to tree. In the chimpanzee the arms, although longer than the lower limbs, are employed to an almost equal extent in locomotion. In the gorilla we see a strengthening of the legs ; the foot has become an organ for supporting the weight of the body, and has lost some of the features which make the typical anthropoid foot a grasping organ. Even among the great anthropoids we see a specialization, not in posture, but in manner of locomotion.

If I have succeeded in carrying the reader with me in my argument he will now realize that the erect posture is a very old one, evolved with the appearance of the gibbons. In the great anthropoids we see a stage which takes us appreciably nearer man; they have the erect posture and also man's bulk of body. Man does not differ from them in posture, but in his manner of progression. He differs from them in being adapted for progression on the ground—an adaptation which allowed him to escape beyond the limits of forests and occupy the whole world. The problem which confronts us is not how man came by his upright posture —that was in existence at an early date—but how and when did he come by his foot, his leg and his thigh? Apparently a long time ago, for although we do not know the foot of Pithecanthropus, the oldest fossil man yet discovered, we may infer from his thigh-bone, which is absolutely human in character, that his foot was also like ours. No human foot has ever been seen, either in human fœtus or in primitive native races, in which the great toe was separated like a thumb, as is the case in all anthropoids, yet from appearances to be found in the human foot itself, the evidence is overwhelming that the great toe was once set like a thumb, and that the human foot was at one stage of evolution a grasping organ. The stages leading from the anthropoid to the human foot are unknown. The foot was evolved before the brain, for in Pithecanthropus—belonging to a very late Pliocene or very early Pleistocene date—the brain is little more than half the size of the modern human brain. It is very likely that the human form of foot and leg appeared when the great anthropoid forms were evolved—probably in the long Miocene period—which was three times as long as the Pliocene period which succeeded it.

It was evolved with the appearance of ground-living anthropoids—one of which we believe stands in the ancestral line of man.

No doubt when we come to know the treasures of "missing links" and of extinct forms of animal life which are at present hid in the more superficial strata of the earth we shall be able to trace step by step the various stages which culminated in mankind. As regards his upright posture we know enough to say that it is an old feature, one which appeared with the evolution of the gibbons. Indeed, the greatest blank in our knowledge relates to the manner, and the time, in which the posture of the gibbons was evolved; yet so close is the structural relationship between the monkeys and the gibbons that there can be no doubt that such a transformation was effected. The next blank in our knowledge relates to the appearance of the human foot, leg, and thigh. There, again, the structural resemblance between the anthropoid and human foot can only be explained by supposing they have been evolved from a common form. Thus, in the body of man there are certain features which are new, some not so new, some old and others older still. His large brain appears to be his latest acquisition; his foot, leg, and plantigrade gait is older, his size of body older still, and his erect posture quite an ancient character—one which probably dates from the beginning of the Miocene period.

CHAPTER VI

THE TAIL AND CERTAIN OTHER VESTIGIAL STRUCTURES

It is very possible that the reader may still entertain a doubt as to the probability of man having come by his upright posture and plantigrade gait in the manner explained in the last chapter. In this one I propose to discuss with him some very peculiar features of man's body which are concerned with posture, and which afford additional evidence that the human stock was not always adapted for the erect posture. The first of these is the human tail. It is not a matter one cares to lay emphasis on, yet for the sake of truth it must be admitted that man is the descendant of a tailed primate. The tail is a direct prolongation of the backbone; all those segments or vertebrae which lie beyond the sacral verbebræ—the ones to which the hind limbs are attached—are tail or caudal vertebræ. In man, these vertebræ, four or five in number and vestigial in size and form, are buried beneath the skin. In the human embryo up to the sixth week, the tail projects on the surface of the body; its projection is best seen when the embryo is in the third and fourth weeks of development. Even at birth a depression in the skin marks the point at which the tail sinks within the body. It is not uncommon to find during dissection of the human body vestigial muscles passing to the coccyx, which represent the tail muscles of lower animals. Well authenticated cases are on record of children who have been born with true tails. Such cases are rare, and the tails are little better than soft string-like appendages, but their structure, and the fact that they form a continuation of the backbone, leave no doubt as to their true nature.

Many years ago critics of Darwin often twitted his supporters on the subject of man's tail; they regarded the theory of a human tail as a joke. A tailless condition is not confined to man; in the anthropoids, both great and small, the tail has disappeared to even a greater degree than in man. In some monkeys the tail has been reduced to a short projecting stump, but only in man and the anthropoids can the tail be said to be completely hidden and reduced to the condition of a coccyx. When it is remembered that it is only these higher primates which have attained the erect or upright posture it will be at once suspected that the disappearance of the tail is a result of a change of posture. There can be no doubt that this is the case. We have seen that when a monkey is held upright its viscera gravitate downwards and need support from below. The muscles which close the hinder end of the body are the muscles which depress the tail; by depressing the tail the monkey can support or shut in the contents of the abdomen. In man, the great anthropoids, and in the gibbon we find the muscles which depress the tail spread out as a muscular hammock across the pelvis to support the viscera. The exact function of the tail in monkeys we do not know accurately; in South American forms it is used as an extra hand; in Old World monkeys it seems to serve as a balancing-rod, for one notices those with long tails now holding them aloft, at other times trailing them behind, first on one side of the branch they are walking on, then on the other. With the evolution of the upright posture the tail became useless as a balancing organ; the centre of the gravity of the body became then quite altered. The muscles which depressed the tail were needed for the support of the abdominal organs, and hence the tail became useless in the new economy which was established and became buried or coccygeal in form. The actual process which leads to the disappearance of useless organs we do not know fully, but we do know that they vanish, usually as in the present case, leaving some mark or trace behind. Thus the disappearance of the tail did not take place when man as we know him now was being evolved; it was even suppressed before the great anthropoids came on the scene. Amongst all the animals now living, the gibbon is the most primitive tailless form, and it was probably during its evolution from a monkey-like form that the tail was lost. Seeing how long the tail has ceased to be a functional organ in the ancestry of man, it is a matter of astonishment, not that it is rarely developed, but that it should reappear at all.

Occasionally men are born with the organs within the abdomen fixed and arranged exactly as they are in horizontally placed—or, to use a better term—pronograde monkeys. Surgeons are well aware of the occurrence of such anomalies, for in these men the bowel being loosely attached by its mesentery, is apt to become twisted on itself, thus causing obstruction. In the earlier stages of development of the human embryo the bowel is attached as in a pronograde monkey, but in the later months the adaptations seen in upright or orthograde primates take place. The small bowel in pronograde animals is attached by a mesentery or sheet of membrane, shaped somewhat like a fan; when the human fœtus enters the orthograde or upright stage of development one side of the mesentery becomes applied to the posterior wall of the abdomen, and thus the bowel is more closely bound down. It would be impossible to explain the facts relating to the fixation of the abdominal viscera unless we suppose that at one stage of evolution, the ancestry of man was pronograde in its posture.

Very little has been said as yet concerning the effect of the upright or orthograde posture on the organs within the chest—the heart and lungs. It is quite evident, however, that when a pronograde animal is held erect not only do its abdominal viscera tend to sink down, but so also do those within the thorax. In the pronograde ape there is a space between the heart and the diaphragm which is filled or occupied by a process or lobe (azygos lobe) of the base of the right lung. In orthograde animals, such as man and the anthropoids, the heart comes to rest on the upper surface of the diaphragm and the azygos lobe disappears. A rudiment of it can always be seen, and occasionally it is of some size, and projects inwards between the heart and diaphragm occupying the same position as in pronograde apes. We cannot explain the presence of a vestige of the azygos lobe unless we suppose that man had passed through a pronograde stage.

There is a danger of becoming tedious were I to press on the reader the technical evidence to be found in man's body which indicates a change in posture. Yet there is an advantage in approaching the study of the human body in the manner I have adopted, for certain functional peculiarities are brought before us which otherwise would escape observation. This is especially the case as regards the shoulder region of our bodies; we are square-shouldered; the military man loves to emphasize this feature by wearing epaulettes. Indeed, the fashionable tailor frequently makes good any deficiency in his customers' shoulders by the use of a little padding. The shoulders of pronograde apes are set quite differently to ours; they are pressed against the flattened sides of the chest, the sharp, keel-like sternum along the lower margin of the body projecting downwards between and beneath them. The muscles are so arranged as to advance and retract the shoulders as the animal runs along. With the assumption of the upright posture in the gibbon, the shoulder is swung round to the side of the body, and the thorax becomes widened from side to side. The shoulder thus assumes the same position as in man, but owing to the fact that the arms are used for suspending the body and for swinging it from branch to branch, the arrangement of muscles between the shoulder and body is peculiar in the gibbon. It is quite clear that when we stand up our shoulders would tend to droop unless they were supported by the muscles which fix them to the head, neck, and spine. Hence there is a slight difference in the arrangement of the shoulder muscles of man, seeing that his arms are no longer used for locomotion as they are in the gibbon and great anthropoids. Now the question we want to answer is the following:—Is there any evidence in the musculature of the human shoulder which indicates that man at any stage of evolution used his arms as anthropoids and as monkeys do? There is. Occasionally a muscle is found in man known as the lifter of the clavicle or collar bone (levator claviculæ) which passes from the neck to the shoulder. It is invariably present in pronograde monkeys, in which it advances the shoulder in running; it becomes modified in its size and attachments in the orthograde apes; in man it has almost disappeared. We cannot account for the occasional presence of this muscle in man except on the theory of a pronograde stage in man's evolution.

I might cite a number of vestigial muscles in the human arm which are well developed in apes. Medical students are aware of the fibrous remnant of a muscle (the latissimo-condyloideus) which is found in the posterior wall of the armpit, uniting a large muscle passing from the back (latissimus dorsi), and another passing from the shoulder into the arm (long head of the triceps). In apes this muscle, which is a mere vestige in man, is a source of strength in climbing. Another instance is seen in connexion with the biceps muscle which bends the forearm on the upper arm. In gibbons this muscle is used for bending the arm as the animals swing along with an ease that a human gymnast might well envy. It is therefore strong and is provided with two extra parts or heads. Now it is a curious fact that these extra heads for the biceps not unfrequently appear in man, indeed one of them, the inner, may be seen in ten per cent. of bodies. It is possible that man and the gibbon may have acquired these extra heads independently, but this is improbable when we take into account the great number of characters they have in common. The third instance I am going to cite of a vestigial or rudimentary muscle in the human arm is the one known as the palmaris longus. In one person out of ten it is quite absent, but the chances are in favour of the reader being able to detect its tendon on his own wrist. If he will look at the front of the wrist, while holding his palm and fingers in a stretched position he will probably see and feel a small cord below the skin passing from the forearm into the palm exactly in the middle of the wrist. In the arms of monkeys he would find this muscle well developed and performing a very useful function. It must be remembered that the monkey uses its hand both as a hand and a foot. The palmaris longus acts on the palm, especially on the skin and pads of the palm, which are rough with papillæ to give firmness of grasp on the trees. The foot-like action disappears from the hand with the assumption of the upright posture, and hence in the anthropoid apes and in man, the palmaris loses its function and becomes very small or may be quite absent.

Beneath the calf of the leg there is an exact counterpart of the palmaris longus. This muscle, the plantaris longus, is also vestigial; it is often little more than a white tendinous cord, having no muscular belly; in five per cent. of men it is altogether absent. The anthropoids are similar to man in this respect; in the gorilla it has almost disappeared. In all pronograde apes it is well developed, and instead of ending on the heel as in man, passes into the sole of the foot, where its tendon spreads out to form a stout membrane (the plantar fascia) under the skin of the sole. As a monkey runs along on all fours, its heel will be observed to be turned upwards off the ground; there is a supple joint—the mid-tarsal joint—just in front of the ankle, which allows the hinder part of the foot to be bent easily upwards. A change in posture, such as is seen in anthropoids, is accompanied by a stiffening of the mid-tarsal joint; the tarsal part of the foot is enlarged to provide a more firm support for the weight of the anthropoid's upright body. The heel is prolonged backwards and the heel is not bent upwards as in monkeys, but the whole sole is applied flatly to the branch as the anthropoid passes along it in an erect or semi-erect posture. When the heel is thus applied to the ground in consequence of the orthograde posture it presses against the tendon of the plantaris; indeed, the heel grows through the tendon, thus cutting off the muscular part in the leg from the tendinous part in the foot. This condition is seen in the legs of man and of the anthropoids, and is proof that all of them have passed through a pronograde stage.

Very probably the reader is aware that in some people, especially those who are kept standing or moving about for hours on a stretch, such as postmen and policemen and nurses, the arch of the foot is apt to break down, producing the condition of flat foot. Only in man is the foot firmly arched; it must serve him as a firm lever as he steps off one foot to take another stride. Now when flat foot develops, the break down of the arch occurs at the mid-tarsal joint—the one which we saw was flexible in the four-footed monkeys and which became firmer as the erect posture was assumed. People with flat foot do not dare to step off their toes because the lever of the foot is destroyed by a loosening or breaking-up of the mid-tarsal joint. It would not be true to describe flat foot as a relapse to a pronograde condition, yet in bending at the mid-tarsal joint the flat foot and the monkey's foot are alike in that they both allow bending to take place.

It has already been noted that man is apt to emphasize those features of his body which mark him off from lower animals and from other races of mankind. The calf of the leg is such a feature; it is highly developed in the white and yellow races—the European and Mongolian. In no dark-skinned race is the calf prominently developed, yet it is in the negroid races we so often see individuals who carry themselves gracefully. Indeed, men who have well developed calves often walk with a jerky step. Anthropoids, like negroid races, have an ill-developed calf, but before pronouncing whether such a feature is Simian or not, it will be well to enquire into its nature. The calf of the leg is made up of two muscles—the gastrocnemius and soleus; they act on the heel. The only difference between man and the anthropoid apes is, that in the former the soleus muscle is larger and has extended the area of its origin to the tibia, while in the latter it is confined to the fibula, but occasionally one sees a tibial origin in the gorilla. There is another difference; while in man the muscle ends in a tendon—the tendo Achillis—some inches above the heel, in the anthropoids the muscular fibres almost reach the heel, the tendon being short. The heel is the lever for the muscles of the calf; if it be long or set horizontally then a less amount of muscle is required to lift the body on the toes; if the heel is short, and especially if it be set obliquely, as is the case when the arch of the foot—the instep—is high, then the heel forms a less powerful lever, and a greater amount of muscle is required to lift it. Now it is notorious that the heel of the negro is long and as his foot has not a high arch, it appears as if it projected backwards to a marked degree. With such a powerful lever the calf-muscles need not be large; they act easily and steadily and give a graceful step. In Europeans the heel is short, and it is bent downwards to form the posterior pillar of the arch of the foot. It forms a less powerful lever and hence the need of greater calf-muscles. It will thus be seen that the history of the calves of our legs is wrapped up in the evolution of the orthograde posture. The anthropoid's leg is a step in advance of the leg of a pronograde ape; man's leg is an equally great advance on the anthropoid condition.

We have thus examined traces of a former pronograde posture in many parts of man's body—in the abdomen, thorax, neck, shoulder, arm, hand, foot and leg; we will bring this chapter to a conclusion by citing one other instance—this time taken from within the body just above the region of the hip joint. In that region of the human body there is found the remains of a muscle named the small psoas—in contradistinction to the great one which bends the thigh. This small muscle is often absent in man, and if present it is small and mainly composed of tendinous or fibrous tissue. It springs from the backbone in the region of the loins, and ends on the brim of the pelvis, behind the outer wall of the lower part of the abdomen. In anthropoids it is not much better developed than in man, but in pronograde apes it is robust and strong. The four-footed apes employ this muscle to flex the pelvis on the spine, its action being well seen as the animal bends its body preparatory to a jump. With the disappearance of this action in the upright posture, the need of the small psoas muscle disappears. Its persistence in a vestigial condition in man and anthropoids shows that they have passed through a pronograde stage.

Although the evolution of the human method of progression was attended by a profound alteration in the form and action of every muscle and bone in the lower limbs, yet this great transformation was produced without the appearance of any really new element. One new muscle—the peroneus tertius—did appear, and the history of its evolution throws an interesting side light on the origin of new structures. It arises by the outer fibres of the common extensor muscle of the toes being separated. In all the anthropoids the feet are so articulated at the ankle joints that the soles are directed towards each other, and only the outer edge of the foot comes to rest on the ground when the animal tries to stand. The feet have a tendency to assume a similar position in children at birth. The advantage of a muscle, such as the peroneus tertius, is apparent in the human foot, for it tends to raise the outer border of the foot, so that the sole is properly applied to the ground. If we examine the muscles which, rising from the front of the leg, cross the ankle joint to end on the back of the foot on the toes in fifty men, we shall find every stage in the evolution of this muscle. In one man at least it will be undeveloped; in two or perhaps three it will be represented by a part of the tendon of the extensor muscle of the little toe, which in place of ending entirely on the toe, sends a part to end on the metatarsal bone of the little toe. In only forty of the fifty men will the peroneus tertius he found quite isolated from the parent muscle—the extensor communis digitorum, and to have a distinct origin from the fibula in the leg, and a separate insertion to the base of the fifth metatarsal bone in the foot. In a series of fifty specimens every stage in the isolation of this new muscle will be seen. It has never been found in any anthropoid, and is more often absent or undeveloped in African than in European races.

It can be very well understood that the

extension of the human thigh, so that it is brought into line with the trunk, must lead to a considerable alteration in the structures of the groin. There can be no doubt that the extension of the thigh has weakened the human groin, and made man more liable to suffer from ruptures or hernias than any other animal. The escape of the contents of the abdomen—which constitutes a hernia—is liable to occur at two points: (1) at the point where the testicles perforate at the groin—just before birth; (2) by another passage which is formed at the inner side of the great vessels of the thigh. The second passage is only found in man, and is due to the manner in which the human thigh is attached to the pelvis. The first opening is found in nearly all mammals, but in man—owing to the width of the thigh and groin—the passage made by the testicle is not so well protected by suitable closing or sphincter muscles as in other mammals. Thus man's upright posture has been obtained at a sacrifice; the modification of the groin has weakened the abdominal wall at the root of the thigh and made him liable to a malady which cripples the strength of many men. The ligament which crosses the groin—known as Poupart's ligament—is peculiar to man, but the complex of structures out of which it has been evolved is very apparent in the groins of the anthropoid apes.

CHAPTER VII

THE DEVELOPMENT OF THE HUMAN BODY

THE reader will observe that I am not following the orderly methods of those who write text-books of anatomy; there is no attempt here to describe one part of the body after another in regular sequence. My aim is rather to bring forward the general opinions held by those who have made a special study of the human body. In the four chapters which precede this one I have touched on the evidence which has led us to regard man as having arisen in a long past period in common with the animals to which he is allied in structure. If such is his origin, then we ought to find further evidence of it during the various stages he passes through before birth. Indeed, it was at one time expected that when we came to know all the changes which the human body passes through from conception to birth, we should have a complete picture of the past history of mankind. It was expected that the embryo would recapitulate the features of its ancestors from the lowest to the highest forms in the animal kingdom. Now that the appearances of the embryo at all ages are known, the general feeling is one of disappointment; the human embryo at no stage is anthropoid in its appearance. The truth is, we expected too much; we failed to realize that higher animals are adapted for two lives—one a peculiar vegetative existence within the womb, and the second a conscious life which commences with birth. The most marvellous adaptations to be seen in our bodies are those which relate to the phase before birth. At a very early stage of development we see the embryo become enveloped within a double-coated hull or membrane, developed as an outgrowth from its own body. Within these membranes the embryo develops, but there never was, there could not be, an individual or ancestor which passed its whole life thus enclosed within an envelope of fœtal membranes. The inner of these membranes—the amnion—is filled with clear fluid within which the embryo floats, evenly supported on all sides and protected from irregular pressures which would distort its delicate growing tissues. The outer membrane—the chorion—gives rise to the placenta which fixes itself to the mother's womb and draws from it nourishment and oxygen for the supply of the embryo, which as is grows and takes on a definite form comes to have the name of fœtus applied to it. The embryo develops its own blood and its own vessels ; its circulation at all times is distinct from that of the mother; there is no intermingling of maternal and fœtal blood. The fœtus is a parasite ; beginnings of a digestive and of a respiratory system appear in it, but they do no work ; these functions are performed by the placenta. All the early stages of development of the embryo are marked by the efforts to produce the structures which are necessary for fœtal life. The provision of such structures marks the true nature of the embryo. The conditions under which the embryo and fœtus live, grow, and draw their nourishment, are very different from those which surround low forms of animal life. We cannot expect the embryo to reproduce for us the early ancestral stages of life ; these have been much modified and some of them replaced to suit the phase of existence within the womb.

Yet in a broad way we see various stages indicated during the building up of our bodies. The fertilized egg or ovum, which forms the commencing stage for each one of us, represents in its structure the lowest forms of animal life —the protozoa. The ovum, like a protozoon, is a cell with a nucleus—so small that seven hundred of them could be laid side by side on a line scarcely an inch in length. The ovum divides, each cell thus formed redivides, the cells arranging themselves so as to form a minute plate-like structure—the embryo. It is impossible to explain certain appearances of the embryo, the streak seen along it, and an opening—the blastopore or primitive mouth—which perforates the embryonic plate, unless we suppose that we had in our ancestry a form built on the same type as the hydra made familiar to us in our text-books on biology. The blastopore is regarded as representing the mouth of a hydra-like animal; it is soon closed in the human embryo, and by the third week there is a new mouth formed at the opposite end of the embryonic body, which becomes the permanent one. The early formation of the fœtal membranes, which enclose the embryo, and the accumulation of yolk within the embryo—an early provision for nourishment—mask and disturb the hydra-like appearance of the embryo. In the next stage we see the rudiments of the body cavity being formed—the pleural and peritoneal cavities which enclose the viscera of the thorax and abdomen. During the development of worms and many other invertebrates, we see body cavities being produced in essentially the same manner as in us, and we therefore suppose that our ancestry and theirs must have passed through a common stage. At the end of the second week we see transverse lines appear one after another on the upper or dorsal surface of the embryonic plate, which mark out the embryonic body into a series of segments, very similar in appearance. These body segments remain particularly distinct in worms, insects and crustaceans; they can also be seen in all vertebrate animals, when the skin is removed. In fishes, the segmental arrangement of the muscles, as well as of the vertebræ and ribs, is especially distinct. In our bodies the vertebræ and ribs still mark the primitive segments, and the intercostal muscles and some of those which act on the spine still preserve the original segmented condition. By the end of the third week, when the human embryo is about one-sixth of an inch in length, the process of segmentation is complete. In a broad way, in spite of special developmental adaptations, the human embryo does recapitulate some early stages of evolution.

It is during the third week that there appears on the neck of the embryo one of the most remarkable manifestations of a past stage of existence. On each side four grooves or depressions are formed. There can be no doubt that these represent the gill slits of fishes. We have every reason to suppose that the arches on the front and sides of the neck of the embryo represent the arches which carry gills, for into each one of them the aorta from the heart sends a branch, in the same manner as may be seen in the gill arches of fishes. No gills are actually developed because the placenta serves their purpose—that of respiration. Indeed, the clefts never open, but part of the first cleft remains, and forms the ear passage. Our ears are developed round the upper part of the first cleft. The lower jaw is developed in the first arch; the hyoid bone, on which the base of the tongue is set, is formed within the second and third arches. The cartilages of the larynx—the thyroid and cricoid, and also the cartilaginous rings of the trachea and bronchi, are formed within the fourth and fifth arches. It is passing strange that we can recognize the same skeletal parts in our throats as we can see in the gill region of fishes. By the sixth week all outward appearance of gill slits is lost; the manner in which the hinder ones disappear is instructive. In certain fishes the gills are covered by a lid or operculum, which grows back over them from the second arch, thus enclosing a gill chamber. In the human embryo a similar process is seen to occur. The third and fourth clefts are covered by a fold which grows backwards over them from the substances of the second arch, and as it grows back the clefts and gill chamber are obliterated. This is not always the case, however. The surgeon is frequently consulted by patients who complain of a discharge which escapes from a small opening situated on the one or the other side of the neck just above the inner end of the collar-bone. When a probe is passed within the opening it passes upwards in the direction of the larynx for perhaps an inch or more. Such a fistula or opening represents the unclosed gill chamber. Occasionally other remains of gill clefts are found as tags of skin or as auricular appendages on the upper part of the side or front of the neck. In some breeds of goats such appendages occur constantly.

Some of the common malformations of the body appear to reproduce a condition which is only seen in fishes. The deformity known as "hare-lip" is a case in point. The name, however, is a misnomer, for the cleft in the upper lip of the hare is situated below the septum of the nose and separates the lip into a right and left half. The cleft, however, which is apt to appear in the human upper lip occurs to the right or to the left of the middle line; the cleft may be double, so that the lip is divided into a middle part attached to the septum of the nose and two larger lateral parts continuous with the cheeks. The explanation is found in the manner in which the upper lip is formed in the fœtus; it is produced by the fusion of three parts. If these fail to unite, the condition of double hare lip is produced, leaving a cleft or groove between the nostrils and the mouth. Now the only adult vertebrate animals in which such a condition is seen to persist is the group of fishes to which the sharks and rays belong. In "hare-lip," then, we appear to see the reproduction of a condition known to occur only in gill-breathing vertebrates.

Cleft palate is often combined with hare lip, but it represents an arrest at a later stage of evolution. A complete palate, such as is seen in man, occurs only in mammals. The palate has been evolved in connexion with mastication; it separates the respiratory passage of the nose from the mouth, so that the animal, as it masticates a mouthful of food, may continue to breathe freely. While the parts of the upper lip are united before the end of the second month of development, the right and left outgrowths which meet along the roof of the mouth and form the palate are not completely joined until the end of the third month. In cases of cleft palate the process of fusion does not take place. Another use of the palate is seen at birth. If it is cleft, the child has a difficulty in sucking and swallowing, for the milk regurgitates through the nose. In amphibia, reptiles and birds, the three parts representing the upper lip unite, but an open cleft remains between the mouth and the nose. In a child suffering from cleft palate we see reproduced a reptilian condition, and have at the same time an illustration of the uses of the palate.

Organs are often arrested in their development on the point of passing from one stage to another. Children are occasionally born with malformed hearts, which illustrate the truth of this statement. In gill-breathing animals, the chief function of the heart is to pump the blood to the gills; after leaving the gills the oxygenated blood enters the arteries and is circulated to the tissues of the body. When gills are replaced by lungs, the heart becomes changed in form and in function. Its main duty is then to pump blood to the body, only a part of the heart—the right ventricle—being set aside to supply blood to the lungs. Now, at the time when the gill clefts appear in the neck of the human embryo, the heart is like that of a fish. It is composed of four chambers, the one leading to the other. The first of these is named the sinus venosus; it receives the blood from the body and passes it on to the next chamber, the auricle. It in turn sends the blood to the chief chamber—the ventricle. There is a fourth chamber—the bulbus cordis—situated between the ventricle and the aorta. The aorta carries the blood to the gill arches. When the gill arches begin to disappear in the human embryo and the rudiments of the lungs are formed, we see the heart, still beating, for it starts to beat very early, begin to undergo a series of changes. The first chamber—the sinus—becomes incorporated in the right side of the auricle, while the fourth chamber, or bulbus, sinks within and forms part of the ventricle. While the sinus and bulbus are being included, developmental changes are seen to be taking place in the auricle and ventricle, which lead to a division of each of these into right and left cavities. The right chambers receive the venous blood and pass it onwards to the lungs and placenta, while the left receive the blood from the lungs and placenta and supply it to the body. The commonest malformation of the human heart is due to an arrest of development during the passage from the gill breathing to the lung breathing stage. In the malformed hearts of children one usually finds that the fourth chamber, or bulbus, has been incompletely incorporated in the right ventricle, and that it is so small that the blood can scarcely pass into the pulmonary artery and thus reach the lungs. Indeed, such children would die from suffocation at birth were it not that the septum between the ventricles is incomplete, so that the impure blood can pass from the right ventricle to the left, and be pumped with the pure blood to the body. Some of it, by an indirect channel, reaches the lungs, where it is oxygenated, and thus the child is prevented from dying of asphyxia. In some cases, there is only a common ventricle as in the fishes and amphibia, the septum, or partition which separates the original ventricle into right and left chambers, having failed to form. The rapid transformation of the heart of the embryo from a simple pump as in fishes into the double-chambered heart of the mammal is very wonderful, and yet not more so than the transformation which produces a butterfly from a caterpillar.

We see a rigid economy being practised in the human embryo, as the branchial or gill stage is replaced by a pulmonary system. There are altogether six pairs of gill arches; into each of these the aorta sends a vessel, or stem. When the branchial arches disappear, the aortic branches within some of them are utilized for other purposes. Those in the third pair of arches form part of the two internal carotid arteries; the vessel of the fourth arch on the left side forms the bend of the aorta, while the sixth one of the left side has a most remarkable history (see Fig. 2). Part of it becomes the stem of the pulmonary artery—the great vessel to the lungs—while the other part remains open only during fœtal life. This latter part, which is known as the ductus arteriosus, allows the blood to pass from the pulmonary artery to the aorta (Fig. 2). The need for such a channel in the fœtus will be very apparent to the reader, when he remembers that the lungs come into use only at birth. Before then the placenta serves the purposes of respiration. The presence of a communication between the pulmonary artery and aorta allows the right ventricle to pump the impure blood into the aorta and thus to the placenta, instead of to the lungs. At birth the ductus begins to close and is soon occluded, so that the blood can no longer enter the aorta but

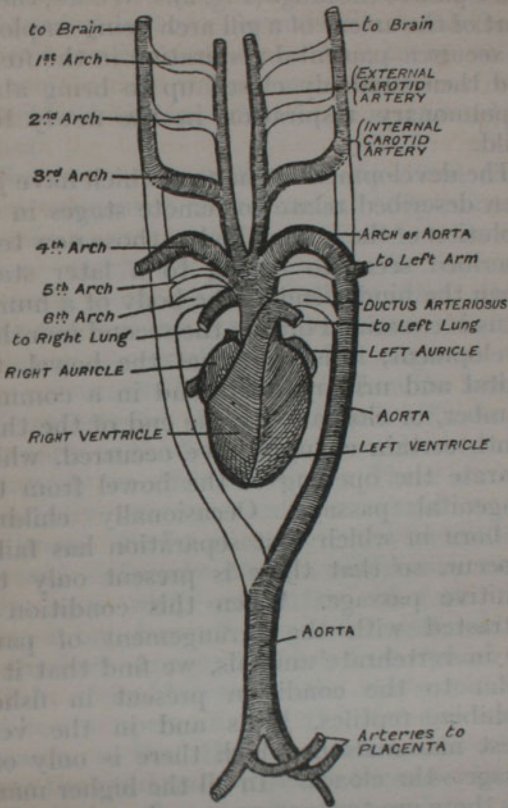

FIG. 2.—Showing how the great arteries of the thorax and neck are derived from the arteries of the gill-arches.

must pass to the lungs (Fig. 2). We see, then, a part of the artery of a gill arch being employed to secure a placental respiration in the fœtus, and then suddenly closed up to bring about a pulmonary respiration in the newly born child.

The developmental changes which have just been described relate to remote stages in the evolution of the human body ; those now to be described seem to belong to a later stage. When the hinder end of the body of a human fœtus is examined during the second month of development, it is seen that the bowel, the genital and urinary ducts end in a common chamber, or cloaca. By the end of the third month certain changes have occurred, which separate the opening of the bowel from the uro-genital passage. Occasionally children are born in which that separation has failed to occur, so that there is present only the primitive passage. When this condition is contrasted with the arrangement of parts seen in vertebrate animals, we find that it is similar to the condition present in fishes, amphibia, reptiles, birds and in the very lowest mammals in which there is only one passage—the cloaca. In all the higher mammals there are two passages, and we infer that the division of the posterior vent must have occurred when the marsupial stock branched off from the ancestral line of the higher mammals and therefore at a date long prior to the appearance of the human stock. In the subjects of the unfortunate malformation just described, we see a reversion to a stage of evolution much less remote than those maldevelopments connected with the imperfect heart and branchial arches.

The instances we have so far cited from the development of the human body indicate in only a general way certain evolutionary phases which are long past. We are now to see if there are any malformations which indicate for us one of the later phases of human evolution—especially such a stage as we may presume to have existed when the human and anthropoid stocks diverged. There are two parts of the body which may be expected to supply us with evidence. These are the essentially human structures—the foot and the brain. So far as concerns the foot, it may be said definitely that a child has never been seen with an anthropoid foot. Yet there is one form of congenital malformation of the foot—congenital club foot—which has certain resemblances to the ape's foot. It is like the ape's, in that the feet are turned inwards, so that the soles face each other; when the child walks it places the outer border of the foot on the ground as the ape does. But the great toe differs from that of the ape; it is not set on the sole as the thumb is in the hand. Yet in the sole of the foot of even the normal child there may be seen the same fold which is present in the ape's foot between the root or ball of the great toe and the rest of the sole. In Eastern races the great toe can be used for grasping objects.

The brain may be arrested in its development. The best examples are to be found in small-headed or microcephalic idiots. There are many cases on record, but the one I propose to bring before the reader is the brain of "Joe," which was investigated by the late Professor Cunningham—one of the best anatomists of our time. Joe's brain weight was 560 grammes, 900 less than that of a normal man and only slightly heavier than that of a gorilla. He was 5 ft. 9 in. high and died at the age of sixty. His head was very small, especially in comparison with his face, which was of normal proportions. He spent the latter part of his life in the county asylum of Lancashire, where he tended the sheep, keeping them within "prescribed limits" with great vigilance for days together. He had command of a considerable number of words and could frame sentences. The expression of his face "was distinctly human," and although he had a vacant imbecile look, his face clearly reflected every emotion in a perfectly human fashion. He knew a sixpence from a fourpenny bit; he could count his fingers, but did not know much about the divisions of time; he was easily puzzled, and did not know how many *years* there were in a *week*.

When "Joe" died, his brain was found to be not only small in size, but to have its fissures and convolutions arranged in a very simple manner. Professor Cunningham was an extremely judicious and cautious observer. The features of "Joe's" brain could not be explained by supposing it had simply been arrested at a certain stage of development, for although the fissures and convolutions had resemblance to the condition seen in the fœtal brain in the seventh month, yet there were other additional and modifying features which he was inclined to regard as the reproduction —an imperfect reproduction perhaps—of a stage in the evolution of the human brain. Certain appearances were really anthropoid in nature, yet in complexity of pattern "Joe's" brain was simpler than that of a chimpanzee. The posterior or occipital part of the cerebrum was particularly small; we know that it is just this part which forms a relatively large part of the brain of the primates. The fissure of Sylvius was placed obliquely, and that area of the brain—the Island of Reil—which is submerged and hid in the fissure in the normal human brain, was exposed and its front part was continuous with the inferior frontal convolution as in anthropoids. The parts of the brain connected with speech were as small as in the anthropoid ape. It seems possible then that such a brain as that of "Joe" does represent, in a disturbed and somewhat distorted manner, an actual stage in the evolution of the human brain.

The most remarkable instance of the close relationship between the anthropoids and man is to be found in their earliest stages of development. It is only within the last fifteen years that we have got to know these stages. The late Professor Emil Selenka spent his fortune and his leisure in procuring and in investigating the embryos of anthropoid apes, and several observers, both at home and abroad, have published exact accounts of human embryos under fourteen days old during quite recent years. Not only is the uterus of the anthropoid and of mankind similar in form, but their embryos become implanted in an exactly similar manner, a manner which is only known to occur in them.

In mammals generally the embryo is distinctly in process of formation before the double membranes grow up and envelop it (p. 95); in man and anthropoids the formation of the embryo remains in abeyance until the membranes are developed. Once these are completed, the small knob of cells which represents the embryo begins to take on a definite shape. The reader will have observed that I have often employed posture to explain the many points of similarity in the structure of anthropoid and man, and will at last feel certain that in this case no such explanation can be offered. On the contrary, it is my opinion that, by some mechanism which we do not know at present, the early development of the embryo has been changed by the posture of its parent. The uterus is situated in the lowest part of the abdomen. In upright primates it is exposed to a special degree of pressure, not only from the weight of the superincumbent viscera, but also from the compressing action of the musculature of the abdominal wall which comes into action in balancing and in all great muscular exertion. Whether this explanation will stand the test of time or not, the fact remains that the resemblance which we see between man and the anthropoids in the adult stage is already present in the very earliest stages of development.

It will be now apparent to the reader why the various stages in the ancestry of man are so dimly represented during the development of the human body. It is because all the processes of development are modified to adapt the embryo and fœtus to an intra-uterine and parasitic life. We cannot, however, explain the origin of the human body from a single cell, the appearance of gill arches, the formation of a cloaca and the occurrence of other developmental processes, unless we suppose man to have been evolved from the very lowest forms of animal life. We see traces of various stages of his evolution. Many of his most primitive embryological structures he shares with other vertebrates. These have not been mentioned. For example, we see during his development three sets of renal organs appear, the one succeeding the other. There is first the pronephros or head kidney which persists as a small appendage of the testicle of man and of the Fallopian tube (oviduct) of woman. Then a second kidney—the mesonephros or Wolffian body appears. This renal organ forms part of the seminiferous duct system in man and a vestigial organ in the broad ligament of the uterus in women. It is not unfrequently the seat of disease in women. Then the third or final renal organ—the kidney—appears. In having a triple succession of renal organs man is like other mammals

CHAPTER VIII

HUMAN MONSTERS AND MALFORMATION

In several of the preceding chapters we have been content to sit still and discuss various aspects of the human body. The time seems to have arrived when we should again see and examine the objects which are to be the subject of consideration. We propose then to revisit the Hunterian Museum where we may critically examine the most complete collection which has ever been brought together to illustrate the various monstrous forms which the human and also the animal body occasionally assume. Before actually surveying the gallery of the museum in which the teratological collection—so this series is named—is arranged it will be to our advantage to see first the specimens which illustrate the formation of normal children. Two preparations show us that as many as five children may be produced at one birth—all of which are small but normal in shape. Triplets are not uncommon; in every 7000 announcements of birth one may expect to hear of a case of triplets. Twins are common; in Ireland a twin birth has a frequency of one in seventy-two, in England about one in seventy-five, and in France about one in a hundred. In man, as in all the higher primates, one at a birth is the rule. Indeed I cannot remember any case of twins being born to either monkeys or anthropoids. We may regard the production of twins in the higher primates as an abnormality. We shall see presently that nearly all human monsters are the result of an imperfect production of twins.

On the adjoining shelves we have an opportunity of verifying the fact that there are two kinds of twins. In one form we see that each fœtus is wrapped in its own membranes; each has its own umbilical cord which conveys the blood to and from the placenta; the two placentas may be partly or completely fused. In the other kind the two fœtuses are enclosed together within the same envelope of membranes; each has a cord but they end on the same placenta. These two varieties of twins we believe arise quite differently; in the first kind there were two ova, both of which were fertilized; in the second there was but one ovum, which, at an early stage of development, divided into two and thus gave rise to two embryos. In the first kind the twins may be of opposite sex and with no greater resemblance to each other than a brother has to a sister, but in the second kind they are "identical twins" both being of the same sex and so alike that even the nurse finds a difficulty in telling one from the other.

It is in the production of identical twins that monsters arise. A fowl's egg which has been prepared to show the embryo of a chick at the end of the twenty-fourth hour of incubation helps us to understand the process. The chick embryo forms a small plate, spread out on the yolk. With a magnifying glass it can be seen that the posterior end of this particular embryo has undergone a process of division and that while the head end shows the rudiment of but one chick, the hind end possesses the basis for two. Another specimen shows a subdivision or duplication of both the front and hind end of the embryo, a condition which would result in twin chicks joined together by their bodies. We are now in a position to understand the various forms of human monsters shown in the teratological collection.

The specimens in the first case of the teratological gallery need not detain us, yet in a way they are very interesting. They show to us the inward parts of individuals in whom the viscera have been transposed. The apex of the heart is directed towards the right side, and its beat, instead of being felt during life in the fifth intercostal space of the left side of the chest, is palpable in the corresponding space of the right side. The arch of the aorta, instead of bending to the left turns to the right.

The cæcum and appendix occupy the left side of the lower abdominal space in place of the right. In short we see the viscera reversed as in a mirror. Such a condition is not common although many cases have been placed on record, but no satisfactory explanation has been given of how the transposition has been produced embryologically.

The next series of specimens shows us products of human birth which none but an expert would recognize as children. They seem shapeless packages wrapped in wrinkled human skin; no head, merely a trunk with projecting parts which simulate limbs. Some are cut open to show that within them there are a backbone, a stomach, liver and bowel, but there is no brain and the heart does not seem capable of acting as a pump. We have come to know that all of these "acardiac" or "parasitic" fœtuses are never born alone; they are the twin of a normal child. The developmental separation of the twins was almost complete; the only junction which persisted was a union between their vessels at the placenta. One of the twins became a parasite on the other; the weaker twin, instead of maintaining its own circulation, came to trust to the heart of the larger or "host" fœtus for a blood-supply, with the result that its own heart became passive and life was maintained by the blood supplied to it from the host or stronger fœtus. The parasitic fœtus cannot survive birth, for the moment the cord of the normal twin is tied its supply of blood is cut off and it dies. The shapeless masses of humanity show us the form and organization our bodies would assume were we to become purely parasitic or passive in our manner of life.

The monsters included in the next series are manifestly the result of imperfect separation of identical twins. In some the body is single down to the navel, but is double from that point downwards; in other cases it is the upper part which is double—two heads and four arms—while the lower parts are those of a normal individual. In others the separation is almost complete, the bodies being united at one point only. In some monsters, as in the case of the Siamese twins, only the parts between the breast-bone and the navel are united. The united twins may grow up and one may die while the other lives. In such cases the surgeon has attempted to preserve the surviving individual by severing the bond between them, but in most instances with very little success. In his well-known work on the *Pathology of the Fœtus* Dr. J. W. Ballantyne gives an account of a remarkable case which occurred in Scotland in the reign of James IV. Two boys were born so united that they were as one individual from the waist downwards, but in their upper parts formed two individuals joined or fastened to each other back to back. These "Scottish Brothers" were excellent musicians and linguists and lived to the age of twenty-eight, when one of them died. "For which many required of the other to be merry. He answered—'How can I be merry, that have my true marrow as dead as a carrion on my back, which was wont to sing and play with me? Therefore I pray Almighty God to deliver me out of this present life'" —a prayer we may be sure that was soon granted. In a historical case which dates back to the twelfth century a pair of twin sisters, known as the "Biddenden Maids," were born in Kent, and were found to be joined from the waist downwards but fastened together side by side. Among the specimens before us there are monsters similar in form to the "Scottish Brothers" and "Biddenden Maids," and many others which illustrate various modes of union. Such united twins are usually placed side by side or face to face. The union however may be head to head or the opposite ends of the body may be joined. All degrees of union, from a slight bond to an almost complete fusion of the two individuals, may be seen. There is one peculiar form in which the heads are fused face to face. In such cases there appear to be two faces, but when they are minutely examined it is seen that these faces are compound, the right half belonging to one head, while the left half belongs to another. Yet so similar are the halves and so accurately are they joined that they appear to form the symmetrical face of one individual, while as a matter of fact they are the united halves of two individuals.

In the united or monstrous twins just described each individual is of equal size and no mistake can be made about their condition, but we now reach a series which is very puzzling in composition, and not easily interpreted, because one of the individuals is dwarfed so that it forms a mere appendage upon a fully grown individual. The human freaks which accompany the travelling showman are usually of this variety. The model of a famous Chinaman is shown in the collection we are at present surveying. Attached to the front of his body immediately below the breast-bone is a curious structure in which may be recognized a trunk, two lower extremities and two dangling processes which apparently represent arms, but where the head should be there is only an indistinct scar. If we suppose one of the Siamese twins to have been arrested in growth at an early stage of fœtal life and become dependent on the other for its blood supply it would have assumed the form of such an appendage as we see on the Chinaman. A year or two ago the writer saw a native of India with a similar malformation. The limbs of the parasitic twin were destitute of movement and of sensation.

Another of the commoner forms of monster is that in which the posterior end of the embryo has been divided, each division of the hinder end of the body being provided with a pair of lower extremities. In many of these cases only one of the two divisions continues to grow, the other being arrested, so that in the adult one may see an extra pair of lower extremities of small size attached to the seat of the normal body or only one of these extra limbs may grow. In such a case the individual may appear to have three legs. In those cases of division of the hind end of the body the sexual parts and anus may be double.

In the case of the Chinaman just described, the head of the atrophic twin had not been developed, but in the specimen which represents the head of the "Bengalee child" we see an opposite condition produced; a head has developed, with no body attached to it. In this celebrated case the child lived for several years; the additional head was upturned with its crown imbedded in that of the living child. The eyes of the additional head could move. An adjoining specimen shows the true nature of the additional head of the Bengalee child. This specimen shows two twins normally formed except that the heads are joined together crown to crown. One can understand that if the circulation were to be cut off from one of the fœtuses, its head might still be supplied from the vessels of the head of the survivor and thus continue to grow while the rest of the body atrophied and disappeared. We see from these experiments which nature has made, and we know now that they are made by the normal condition of development being altered, that the human body during its embryonic and fœtal stages is very plastic and capable of taking on many forms. Monster chicks can be produced by hatching eggs at too high a temperature. If the ova of the sea urchin or of the salmon are hatched in water containing certain salts in solution, many monstrous forms are produced. Medical men have been unable to find evidence to support the widely spread popular tradition that such monsters may be the result of mental shocks or impressions received by the mother during pregnancy. We do not see how such impressions could be conveyed to a fœtus in which all the parts are already formed. On the other hand we can see that fever or altered conditions of the mother's blood or uterus might disturb the normal condition of development, and thus produce monsters. Malformations are very apt to occur in certain families, especially those which are regarded as neurotic.

We are now in a position to consider two specimens which made a sensation when first reported, nearly a century ago. They are very similar, so that only one of them need be described. We select the specimen which is part of a lad who died at the age of sixteen from a tumour which was situated within the upper part of the abdomen. Lying within a cavity in the tumour was found the body of a child very similar in shape and size to the one which we saw attached to the epigastric region of the Chinaman. There was a backbone, abdomen, arms and legs, but no head. Here we are apparently dealing with a twin, but one which at an early stage of development became included within the abdomen of the larger or host twin. The "included" twin was hampered in its growth by its peculiar position, and as we have seen, brought about the death of his twin brother.

Another series of specimens appears to illustrate a condition which is allied to the one just described but in reality is very different. They are hollow tumours or cysts which have been excised by the surgeon and may occur in almost any part of the body, but are found most frequently in the reproductive glands. The interior of the cavity seems to be lined with skin, hence they are named "dermoid" tumours or cysts. They often contain tufts or even masses of hair, and it is quite common to find bony plates on their interior to which teeth of various shapes are fixed. It is not easy to explain the occurrence of such peculiar cysts, but it is possible that they arise from a genital cell—one which under normal circumstances would give rise to ova or spermatozoa.

It is now known that the ova of invertebrate animals—such as that of the sea-urchin—may be stimulated to divide and even form an embryo by the application of a particular chemical solution. It is just possible that dermoid cysts may arise from genital cells which have been situated in abnormal surroundings and subject to irregular stimuli.

It has been shown by various embryologists that the cells set aside for reproduction of another generation are separated from the cells which form the embryo at an early stage of development, and that some of them may never reach the testicle or ovary, but become stranded in the body tissues. From such stray cells it is supposed that dermoids may arise, but such an origin is not yet proven.

On other shelves of the teratological gallery are shown numerous specimens to illustrate the developmental abnormalities of hare-lip, of cleft palate, and of other malformations which have already been alluded to. Nor need those ugly births detain us, in which the top of the head is absent, giving the child a frog-like appearance; nor those in which the spinal cord is exposed as a flat plate along the back. But there are two very curious conditions which may have some interest for the reader. One of the conditions is that of cyclops. The two eyes are fused together, forming a single eye under the middle of the forehead. The condition is one which never could have existed at any stage of human evolution. To understand its origin one must first look at another series of specimens in which the two lower extremities are fused together and stretched out so as to form a continuation of the axis of the trunk. One can see very well how the hind limbs became fused together in embryonic life. They appear first as small flattened buds on the side of the posterior part of the embryonic body. Now if the posterior end is arrested in development the two limb buds appear side by side in their normal position, but being unseparated by the hinder end of the body they fuse together across its hinder end. Arrest of growth may occur at the anterior end of the embryonic body—the most anterior part being that which separates the eyes and forms the middle part of the nose. Hence if an arrest of growth of the middle or nasal part of the face occurs the eye buds are unseparated and they fuse together in the earlier stages of facial development. The anterior ends of the hemispheres of the brain are also joined to some degree. Thus we see that the posterior and anterior ends of the embryo may be arrested in their development, with the result that the hind limbs fuse in the one case, the eyes in the other. The one condition is known as sympodia, the other as cyclops.

In cases of a human cyclops there is often present a small appendage shaped like the proboscis of an elephant. The appendage is situated above the median eye and represents the rudiments of the parts which are normally incorporated in the development of the nose. We cannot suppose that any human ancestor was normally provided with a free proboscis and median eye.

The second abnormality to which we would draw the reader's attention relates to the lower jaw or mandible. It is not uncommon to see a face sadly deformed by an arrest of growth of the lower jaw. Instead of projecting prominently, the chin and lower lip are drawn downwards and backwards so that the face appears to merge into the neck without any sharp boundary between them. The museum specimens illustrate very pronounced examples of this deformity. The arrest in the development of the mandible and of the tissues formed with it from the first visceral arch of the neck, is almost complete. The ear holes, evolved from the upper part of the first visceral (gill) clefts are drawn downwards so that they almost meet in front of the neck. It is possible that this condition may be a reversion, for the lower jaw is very poorly developed in several of the most primitive types of fishes. It is worthy of remark that this condition—known as agnathia—may occur in all the domestic breeds of animals and is especially frequent in South Down sheep.

We will bring this brief survey of monsters and malformations to a conclusion by noting a few of those congenital deformities which affect the limbs. The fusion of the hind limbs (sympodia) and congenital club foot have been already mentioned and need not be further described. It has also been mentioned that the limbs appear as small flat outgrowths from the side of the trunk at the end of the third week of development, when the embryo is only about a tenth of an inch in length. It is a week later before the three limb segments are differentiated—those of the upper arm and thigh, of the forearm and leg, and of the hand and foot. The buds of the upper and lower extremities are at first very similar in appearance. The fingers and toes, when they first appear, are imbedded in the flattened or webbed extremities. Often some degree of webbing persists, and with this condition some of the joints in the fingers or toes may fail to form. Such abnormalities are apt to be hereditary, and to run in families. The limb buds may be arrested in growth at an embryonic stage, and when the individual is quite adult all that may be seen of them are minute tags of skin. It is fortunate for us that such severe errors or diseases of development are of rare occurrence. One of the commonest departures from the normal is the presence of an extra digit. Supernumerary digits may be situated at the little finger or thumb side of the hand. It is possible that the occurrence of a sixth digit may be due to the reappearance of an ancestral condition, but if so it must represent a very early stage in the evolution of the hand and foot, for in all the higher vertebrates the number of digits does not exceed five. Man appears to retain normally the original complement. It is very possible that the extra digit is due to a division or dichotomy of the bud for the little finger or thumb. We have seen that one end of the embryo may divide so as to form a double individual, and it is also probable that this may happen in the bud which gives rise to a finger or toe.

Before leaving this subject we may glance at a form of abnormality which illustrates the fact that when reversions occur in man they usually relate to a very remote stage of evolution. The abnormality to which we wish to draw the reader's attention is a bony process—the supracondyloid process—which is attached to the inner side of the humerus a few inches above the elbow joint. It occurs in one body out of every fifty examined. The preparations show that the main artery and nerve of the upper arm pass under this hook-like process. The supracondyloid process appeared in the humerus of the ancestors of modern mammals; it is seen in many reptiles; the lemurs have it, so have the carnivora and many other forms; but it is absent in all the higher primates except as an abnormality. Its use we do not know, but it is remarkable that this trace of a pre-mammalian stage should so often appear in man. Sir John Struthers showed that it passed from father to son, and one can conceive that it may have persisted in some individuals at every stage of man's evolution.

Mention has already been made of the anomalous position of man's great toe, and of the fact that no case of complete reversion to the anthropoid condition has been observed either in monstrous or normal human births. The evidence that the human great toe was at one time thumb-like and separated from the other toes is, however, convincing, and we have to see how the human condition could have been evolved. It has just been mentioned that when the hand and foot are first formed all the digits are united together or webbed, as is the case in all mammals. The separation of the thumb and great toe is a secondary process. The great toe of man appears to have been evolved by a retention of the condition seen in the embryonic limb. In other words, we may regard the great toe of man, as far as its relationship to other digits is concerned, as having reverted to the primitive mammalian position.

CHAPTER IX

CHANGES IN THE BODY DURING YOUTH AND AGE

In the last two chapters we have been considering the changes which occur in that phase of our lives which culminates at birth. Before surveying those transformations which link infancy to old age it is necessary to emphasize one or two points relating to intra-uterine life. There are really two stages in that life; by the end of the third month all the parts of the body are formed, the active process of development is over. During the last six months of intra-uterine life the changes are those of growth and of maturation. The years which follow birth form a continuation of the latter stage of fœtal life; no new structure or organ is laid down, bone and tooth formation proceed as before, and the tissue cells continue to divide and grow. By the act of birth the economy of the human body is suddenly changed. Up till then the placenta supplied the child with oxygen and nourishment from the mother's blood; birth calls the lungs suddenly into action, and the blood passages and heart undergo a rapid transformation to suit the new respiration. The stomach and bowels have to supply nourishment from food. The remarkable transformation of the lungs, heart and stomach in the newly born child are not peculiar to man; they are the common heritage of the higher mammals.

From birth onwards the body continues to change; there is no stationary period; every year leaves its mark. Shakespeare distinguished seven ages—"The infant mewling and puking in the nurse's arms"—"the whining school boy"—"the lover sighing like a furnace"—"the soldier . . . bearded like the pard"—"the justice in fair round belly . . . with eyes severe"—"the lean and slippered pantaloon"—"second childishness . . . sans teeth, sans eyes, sans taste, sans everything." His description of the age changes of the body is perhaps the most graphic and complete ever penned. Unconsciously every one of us is a student of these bodily changes; so familiar do we become with them that with a glance of the eye we estimate instinctively the age of a passer-by. Our judgment is influenced by many characters, most of all by those of the face. Before we are aware of it we have noted the skin of the face, observed its lines and wrinkles, formed an impression of its texture—in short of its probable age. Of all the tissues of the body the skin and muscles of expression which lie under the skin are the most accurate registers of years. Not one passes and leaves the skin just as it was; every year the tender, soft, suffused, velvety covering of babyhood moves one degree towards the dry, grey, wrinkled and loose integument of the very aged. We never mistake the "baby-fat" which gives the plump rounded outlines of youth for the obesity which may come with middle age. It is true that we do not all grow up or grow old at the same rate; youth persists in some and is delayed in others, so that in this case or that our judgment may be a little astray.

The carriage of the body counts for much; the suppleness of joint, firmness of hand, and agility of limb are marks of youth. The old gentleman, although he walks erect, cannot mislead us any more than the old lady who seeks a means of restoring colour and smoothness to the skin of her face. Our attention is immediately arrested by an incongruity in age of features; a man may have grey hair but his skin, his eyes, his lips and mouth tell us he is still young. Age wipes gradually the sharp outline from the lips and mouth; the eyes become a little duller and the eyelids lose something of their cleanly cut youthful shape. The form of the chest and trunk changes; the body never ceases maturing in manhood nor decaying as age is advanced. We have all studied the age changes of the body in the practical school of daily life. The medical man is well aware that tissues cannot live and not change, and that the appearances of age we have noted in the face are but symptoms of the decay that is attacking all the tissues of the body. The elastic tissue of the skin gradually loses its elasticity; although alive—at least we believe it is—it is less alive than any other tissue of the body and is less endowed with the powers of repair. It is the first to suffer decay. The elastic and muscular coats of our arteries are at their best about twenty-five; that is the age when the hurdler, the footballer—all who have to make sudden physical spurts—are in their prime. The brain attains its most accurate control of muscles between thirty and forty, while as an organ of thought the brain itself is at its best between forty and fifty. We see then that the systems of the body mature and age at different rates, but the collective changes in the body occur so uniformly that when an individual is brought before us we are seldom at a loss in estimating the years that have passed since birth.

Shakespeare's seven ages run their course for most people in the Psalmist's limit of threescore years and ten. How and when did man come by his span of years? We have to seek for evidence in the light of the evolutionary theory. How does the span of life run in those animals which are allied to man—the anthropoids and monkeys? Let us first look at the period of infancy—for that is proportioned to the longevity of the adult. Now the period of infancy may be defined as that in which the milk teeth are erupting. In man, all of the milk teeth—twenty in number—are in place by the end of the second year, but the period in many children extends six months longer. The period of human infancy then may be fixed at two years. In monkeys and in the small anthropoids, the gibbons, the milk dentition is completed before the end of the first year. In some, such as the semnopitheques, the incisor teeth are cut at birth and the dentition is completed in eight months. The gibbons are the most important for our present purpose, because we suppose them to represent a phase in the evolution of the great anthropoids and of man. The period of infancy in the gibbon is then under one year. In the great anthropoids the milk teeth begin to appear some three or four months after birth and this dentition is not complete until some time in the second year. The period of infancy in the great anthropoids, therefore, is probably under two years, but in its extent is comparable to that of man. There is evidence to show that the intra-uterine period of the gibbon is seven months and that in the great anthropoids, as in man, it is nine. We may be fairly certain, therefore, that the lengthening of the periods of fœtal and of infantile life took place during the evolution of the great anthropoid from the small—a period which we have already shown to be at least millions of years ago.

We come now to the period of adolescence, which we may regard as defined by the eruption of the permanent teeth. In man this period may be reckoned as extending from the fifth to the twenty-second year, but we have already seen that eruption of the third molars or wisdom teeth may be long delayed in civilized peoples and may appear at an earlier date in primitive races. In monkeys the adolescent period extends from the end of the second to the end of the fifth year; in gibbons, so far as the evidence available gives us warrant to make a definite statement—from the end of the second to the sixth year. In the great anthropoids the permanent teeth commence to erupt in the fourth year and are all in place before the end of the fourteenth year. In the anthropoids then, the period of adolescence extends to about the fourteenth year, whereas in man it is prolonged to the twenty-second. As to the natural span of life of monkeys and of anthropoids we know nothing, except from animals kept in captivity, but assuming the periods of infancy and adolescence to form one-third of the total life, we may suppose a gibbon at eighteen, an anthropoid at forty-two, and a man at sixty-six to be aged individuals. So far as the evidence goes then it appears that long life in the higher primates came with the evolution of a large body, but that man—at least civilized man—appears to have extended his span of life. Reliable observers assert that the more uncivilized races, such as the natives of Australia, show at forty-two the age change of a European at sixty-two. The facts at our disposal indicate that longevity is an old inheritance of the human stock and that modern man is longer lived than his forerunners.

One of the most remarkable changes of infancy is the rapid growth of the head. Everyone has noted the large head of early childhood, especially when compared with the slender neck which unites it to the trunk. The rate of growth in the head during the period of infancy is altogether out of proportion to the increase in the rest of the body. The facial part of the head does not share in this rapid increase; it is the cranial part—the part containing the brain, which undergoes a rapid expansion. The explanation lies in the mushroom-like growth of the infant's brain. It is of the utmost importance that the organ which is to guide the child through the intricacies of human life should be formed at the earliest possible date. By the end of the second year the child's brain has attained more than half of its adult size; by the end of the fourth year over 80 per cent. of its nerve tissue is already present. Indeed we may say that when a child of five goes to school all its nerve cells are formed and in place; the increase which follows relates to a growth in the size of the child's body, for we know that growth in the size of the body is accompanied by an increase of brain tissue—an increase which is not connected with the higher faculties. It is extremely important to recognize such an element in the human brain and it may be called for convenience the "corporeal concomitant." The rapid increase of the cranial capacity is a character of the human infant. The brain of the newly born gorilla, which is only slightly smaller than that of a child at birth, is already 65 per cent. of its adult size; the remainder of its growth is probably due to the addition of the "corporeal concomitant." From birth onwards, the anthropoid brain continues to increase at almost a uniform rate until adult years are reached; there is no spurt in growth such as we see in the brain of the human infant. The peculiarity of the human brain, then, is its rapid growth in infancy and early childhood. A child at five has only reached that point in the growth of the brain which the anthropoid has attained at birth. Man then is peculiar in that his brain continues to grow rapidly after birth, and in the great expansion of the head in infancy and childhood we see one of the latest phases in human evolution.

The age changes in the face and neck are ruled by other conditions. The face, from an anatomist's point of view, is really part of the apparatus of mastication. It is an accident, as it were, that the face has to accommodate the eyes and the nose. The facial part of the head is a bony scaffolding for the upper and lower jaw on which the teeth are set. As the milk teeth come into place during infancy, the face, still retaining its cherubic roundness of outline, increases gradually in size and strength. During adolescence, as the permanent teeth come into use one after another, the jaws themselves grow to accommodate the erupting molars or chewing teeth; the facial scaffolding is enlarged to support them, while the muscles which move the lower jaw undergo a rapid growth. Every one must have observed that the features of the boy or of the girl, are replaced by bolder and rougher outlines as the last of the teeth come into position. The muscles of mastication which arise on the bony outworks on the side of the skull need stouter supports. The bony ridges of the cheek and skull become emphasized and the features rapidly change. The growth of the neck does not proceed at the same pace as that of the head. Most of us may recall, if our memories carry us back to the details of boyhood life, that every second or third year we took a larger size in collars, while we wore hats of the same size for a number of years on end. The rapid growth of the head took place during infancy and early childhood. At first sight it is not apparent why the neck should keep time in its growth with the muscles of mastication. It is so, however, and the reason becomes apparent when one remembers that the skull, which serves as a fulcrum for the muscles of mastication, must be steadied when these are in action. The skull is balanced and fixed by the muscles of the neck. It will be observed that it is the men with the wide, squarely-set, massive jaws and cheeks who have their heads deeply implanted in their necks. We describe them as strong, bull-necked men—people of a strong will and with a healthy appetite. In anthropoids we find the jaws massive, the muscles of mastication so large that they envelop the skull, and with heads hafted to exceedingly thick and muscular necks. It is as adult years are reached that we see the most marked changes occur in the fixation of the head and in the size of jaws.

The changes in the head and neck so far described are those of infancy, youth and early manhood or womanhood, they are growth changes. Not a word has been said of the changes which set in with old age. There is no stationary interval between the first and the last. By the time the final form of the head has been determined by the processes of growth the changes of decay set in. In some, these are marked by obesity; in many they are emphasized by an absorption of the natural fat, which leaves the skin loose and the skeleton, muscles and veins apparent. With advancing years the muscles of mastication undergo a process of atrophy and the fat round them is absorbed; the temples therefore become hollow, and the bony processes of the skull become surface markings. With the loss of teeth the jaws atrophy, the cheeks fall in, the mouth becomes shapeless. With the atrophy of the jaws and muscles of mastication the neck becomes thin and its skin lies in folds.

We are now to examine a number of changes which occur in the human body preparatory to the assumption of the upright posture. In the latter part of infancy we see the body becoming modified for walking. During the first year the lower extremities cannot support the body, not because they are not strong enough, but because the brain has not yet gained control of the muscles which are needed to balance the body on the feet. Yet Dr. Louis Robinson has shown that a newly born child has sufficient strength in its grasp to support the weight of the body from the hands. The newly born monkey clings to its mother as she takes plunging leaps from tree to tree, by grasping the hair on the under surface of her body with its fingers and toes. The anthropoid, like the human infant, has short legs and cannot extend them into a line with the body. As the infant attempts to stand and walk, the legs are slightly bent at the knees and flexed at the hips. Presently, as the period of childhood is entered and the art of walking is acquired, the lower limbs grow at a faster rate than the rest of the body and peculiar changes occur at the hip and knee joints, which allow the limbs to be completely extended in line with the body, and to be used in standing and walking. While the chick can run the minute it escapes from the shell, the human child has to learn laboriously even the art of standing. In the newly born child the lower limbs form only two-fifths of the standing height; in the adult they form a half or a little more—according to the individual and to the race. We shall obtain a better insight into these remarkable adaptations for walking if we take the combined length of the trunk and head as a standard of measurement. In the human fœtus at the sixth month of development the lower limbs are only 55 per cent. of the head-trunk length; at birth they are, in the average individual, 62 per cent., and in the adult 102 per cent. of the head and trunk measured in a straight line. If we now turn to see how the anthropoids compare with man we find that their lower limbs have about the same relationship to the head-trunk length as in the newly born child—varying from 50 to 70 per cent.—but no special growth takes place in their lower extremities soon after birth as is the case in children. The lower limbs of the adult gibbon are 78 per cent. of its head-trunk length, those of the gorilla 66 per cent., those of the orang 58 per cent. Thus we see that the lower limbs of a child at birth have the same proportionate length as the anthropoid. The peculiarity of man is the rapid growth which takes place after birth and adapts the limbs for standing and walking.

At the same time as the lower limbs are undergoing a special growth in the child another change is taking place in the loins or waist of the body. No one who has closely watched the crawling child trying to stand up, can have failed to notice that it not only raises itself at the hinge or joint between the body and the thighs, but that the trunk is also bent backwards at the loins. The lumbar part of the backbone, which supports the loins between the pelvis below and the chest above, is made up of five vertebræ in man. This part of the spinal column supports and balances the upper part of the trunk. Now in all the great anthropoids the lumbar part of the spinal column is very short; the pelvis is closely knit to the expanded chest. The significance of this feature of the anthropoid spinal column is very apparent when these animals are seen swinging along, sustaining their weight as much from their hands as supporting it by their feet and legs, or even more. They do not habitually support and balance their bodies on the lumbar part of the spine as we do. In the newly born child the lumbar part is 27 per cent. of the total length of the spinal column—the same as in the adult chimpanzee. As the child learns to walk the lumbar region rapidly elongates, so that in adult man it forms 32 per cent. of the total length of his vertebral pillar. Here again we see a peculiar feature of man's body being developed in early childhood—a feature which adapts him to the upright posture. The short lumbar segment is an anthropoid character; it is replaced by a long segment which, as regards the higher primates, is peculiar to man.

These remarkable changes in the loins and lower limbs in early childhood, which have been thus cursorily described, are growth changes which fit the human body for man's peculiar method of locomotion. We recognize how perfectly these adaptations have been evolved from the easy and jaunty manner in which young people carry themselves. When forty years of age or thereabouts is reached, however, the suppleness of the joints and the easy co-ordination of the muscles begin to show some degree of impairment. As old age approaches the muscles shrink from thigh and calf; the knees become bent, the hip joints stiff and incapable of full extension, the back bends and shrinks, while the muscles and joints of the spine fail to maintain the trunk and head in a position of easy balance. Old age wrecks the mechanism of the upright posture for every one of us. Yet in youth it seems such an easy thing to stand or walk.

The chief structural changes which occur after birth are concerned with the growth of the brain and the adaptation of the human body to upright plantigrade progression. These represent the most recently acquired characters of man. It is very apparent, too, that a complete human life is made up of two distinct periods—one in which growth is predominant and one in which decay is predominant; where the one period ends—about the twenty-fifth year—the other begins.

CHAPTER X

THE SEXUAL CHARACTERS OF THE HUMAN BODY

Some years ago Mr. Havelock Ellis collected all the observations which have been recorded regarding the differences between the body and mind of man and woman and made them into a most interesting and valuable book. From the crown of her head to the sole of her foot woman's body differs from man's. She buttons her dress differently, she walks, speaks, and breathes differently. We are so accustomed to the division of mankind into two forms that we never think of the possibility of man and woman being formed alike. Our business in this chapter, however, is not to picture a world populated with men and women, alike in mind and body, except in the essential parts relating to sex. Our purpose is to see what light we can obtain on the origin of the sexual differentiation of mankind, and ascertain if possible how and why the two sexes have been endowed with different characters.

Now, although the thousand and one characters which have been enumerated by Mr.

Havelock Ellis distinguish the parts of the female body from the male, there do occur cases where the distinctions are but ill-defined. It is not necessary to say that occasionally women appear to assume the form of body and features of face we associate with men, while just as frequently we see men who are feminine in their stature and build. In such cases, where we have only a part of the body to provide us with the necessary evidence, it may be difficult or even impossible to determine the sex. This was forcibly brought home to the writer a few months ago when a complete skeleton was excavated on the coast of Essex by Mr. Hazzeldine Warren. It was proved from the objects found with it, and from the stratum in which it lay, that the individual whose skeleton was thus found, had lived 4,000 years or more ago—when the natives of England used rough pottery for cooking and flint knives for cutting. When Mr. Warren brought the skeleton to me I lifted the skull from the box and said it was that of a woman. My judgment was founded on several of its characters. The first and chief was that the bony ridges which give attachment for the muscles of mastication and for those of the neck were not so strongly marked as in the male sex, for in a man these muscles are usually strong and their impressions very distinct. The impressions on the base of the skull for the attachment of the neck indicated the tapering, slender neck of a woman, not the thicker and stronger neck of a man. The bony ridges which cross the forehead were not prominent as is the rule in men. The face, too, was moderately long, oval and slender in form, while the teeth, although well developed and somewhat worn, were small in size when compared with those of a typical man. The skull was small in size. On an average the cavity of the skull of a man holds 140 cubic centimetres (five ounces) more than that of a woman, and is a quarter of an inch longer and one-sixth of an inch wider. In these characters this skull corresponded to those of a woman. I concluded, therefore, that the skeleton must be that of a woman. The reader, however, is already aware that there is here and there a man with a skull which may answer to all of these tests.

Mr. Warren, however, had formed an opposite opinion as to sex, and drew my attention to the pelvis. That part of the skeleton as a rule affords undisputable evidence as regards sex. In the female it is widened so as to give passage to the child at birth. In the specimen from Essex there were all the outward appearances of the pelvis of a small and slender man. It was stout and muscular; the pelvic cavity was neither capacious nor shallow, nor was its outlet wide and roomy as in the typical female pelvis. Although a few of the minor characters of the pelvis were suggestive of the female sex, yet I had to agree with Mr. Warren that the major ones were masculine. There was no doubt as to the pelvis and the skull being parts of the same individual and yet there was apparently an incongruity between their sexual characters. The height of the skeleton indicated a person of 5 ft. 4 in. in stature, that is only half an inch more than the stature of an average woman and three and a half inches less than an average man. The stature indicated again the female sex, but all of us have seen women of 5 ft. 8 in. and men of 5 ft. 4 in. The thigh-bones, the bones of the arm and of the leg were slender, but still not so finely marked as to exclude the male sex. The bones of the hands and feet were small; these were female characters. When, however, we came to examine the ribs, the breast-bone and the chest as a whole, all question as to sex was settled. The breast-bone was of the short wide form which is only seen in women. When the ribs, which were rounded and rather slender in form, were placed in position, it was seen that the thorax was well formed in the upper part, as is usual in women, and fell away in the lower part so as to conform to a narrowing at the waist. When the pelvis was placed in its proper position as regards the thorax it became evident that in spite of its masculine characters it was much wider than the thorax. The width of the lower or pelvic part of the body as compared with the breadth of the thorax is a striking feature of the female body. In males the pelvis is usually narrower than the chest. In statues and paintings of the nude, this character of the female body is always to be seen. A certain degree of narrowing at the waist is natural to a woman, for we are dealing here with one who lived long before the days of corsets. The short breast-bone, the well developed upper part of the chest are adaptations to woman's natural method of breathing. She uses the upper part of her chest more than the lower part in breathing, while men usually do the opposite. It is true that this statement has been denied and that observations made on primitive races have been published to show that man and woman, in a condition of nature, breathe alike. My own observations point to an exactly opposite conclusion, and in this I am in agreement with the majority of students of the human body. There can be little doubt that woman's breathing is modified so as to minimise the pressure to which the developing fœtus would be subjected in the later months of child bearing if the type of breathing were abdominal or diaphragmatic as in the male.

From the survey which has been given it will be realized that every part of the skeleton is modified in connexion with sex. Further it will be evident that there is a variation in the degree to which these characters are developed from individual to individual and from part to part. For instance, in the case just related the female characters of the pelvis were not apparent until it was contrasted with the thorax. It often happens, however, when we have to deal with individual skulls or limb bones that great difficulty is experienced in determining sex. Most anatomists agree that in every hundred skulls there are five at least, possibly ten, of which the sex cannot be postulated with any degree of certainty. This is particularly the case when the skulls are those of women who have passed the age of child bearing, for after that period growth changes often set in.

The problem of the origin of sexes does not concern us here; it is sufficient to say that long before the very lowest forms of vertebrate animals had been evolved, individuals were already born either male or female. The questions one would like to answer are the following: Have man and woman always been as sharply marked off from each other as now? Is the sexual difference really decreasing or increasing? Is it possible that the day may come when to all outward appearances man and woman may seem the same? We turn to the evidence which the anthropoids can afford us. The most primitive—the small anthropoids or gibbons—show us the sexes so alike that it is hard to tell the male from the female. The female is the heavier animal; her canine teeth are as long and sharp as in the male; the muscular ridges in her bones are equally well marked. Yet there are minor differences between them, but they are not so decisive as to allow us to determine sex except by examining the essential organs of generation. Here, then, is a primitive condition showing an apparent equality in sexual characters. In the great anthropoids the sexual differences are very marked. These are most pronounced in the gorilla, the anthropoid which stands nearest to man if we take all the characters of the body into account. In mass of body, in muscular development, strength of limb, size of jaws and teeth, the male gorilla exceeds the female to a greater degree than man overshadows woman. The male is the fighter. Amongst chimpanzees the difference between the sexes is about the same in amount and in kind as in the human species. Amongst orangs the sex characters are more marked than among chimpanzees, but less than is seen in gorillas. The canine or eye teeth mark the sexes of the great anthropoids. They are especially large in the male gorilla and are most reduced and therefore most nearly resemble the human canine in the female chimpanzee. Among human races the canines have fallen to the level of the other teeth in both male and female, yet we must infer that at one time they were large in size with prominent conical points, just as in the great anthropoids, for their buds are formed deeper in the jaw than the other teeth. The buds of our canine teeth are formed in the same anomalous position as in the chimpanzee and gorilla.

There is also a sexual difference as regards the brain. The male anthropoid has much the heavier brain. Amongst gorillas the male brain is eighteen per cent. larger than that of the female, amongst orangs fourteen per cent., and amongst chimpanzees eight per cent. ; while in human races it is about twelve per cent. When we sum up the bearing of these facts on human history we must infer that the differences which we see between the bodies of man and woman are of old standing. The great anthropoids show about the same degree and the same kind of sexual differentiation. Man and anthropoid seem to have inherited their sexual characters from that common stock of primates which appeared many millions of years ago in an early stage of the Miocene period. Even in the most remote and dark period of jungle existence we see that the body of man is specialized in one direction, and that of woman in another. It is a standing law of Nature that a difference in the structure of the whole body signifies a different function in the whole body. We must, therefore, conclude that before the period of civilization dawned on the world the bodies of man and woman were already specialized for different sides of human life. Legislation can give the sexes equal opportunities of life, but it cannot blot out the structural differences between man and woman. These have taken geological epochs to produce. When, too, we see that the degree of sexual differentiation is just as marked in high as in low races of mankind we must infer that there is no evidence to support the idea that civilization will in time produce a structural equality in the two sexes.

We can obtain further light on the nature of our sexual characters by watching their development in the fœtus and child. Although we have reason to believe that the sex of the individual is already determined when the human egg is fertilized, we cannot distinguish a male embryo from a female until the second month of development is nearly finished. When the anatomy of a human embryo of this stage is examined it is seen that there are four tubes passing side by side within the hinder part of the body to end in the common cloacal passage or exit. The two inner or middle tubes become the oviducts or channels for the two genital glands of the female; the two outer or lateral ducts—the sperm or Wolffian ducts—become the passages for the two male glands. Before the end of the second month it becomes possible to tell whether the two genital glands are to be those of a male or of a female. The gland assumes either the structure of an ovary or of a testicle. As soon as the characters of the glands are determined we see changes taking place in the genital passages. If the sexual glands are those of the female the oviducts grow together, fuse in their lower parts to form the uterus, while the upper parts remain separate and form the Fallopian tubes or egg-ducts. On the other hand, the two lateral or Wolffian ducts are arrested in growth, and only vestiges of them persist. If the sexual glands of the embryo are of the male character —testicles—the lateral or sperm ducts develop, while the oviducts become reduced to vestiges. In the male fœtus the cloaca becomes enclosed to form a male organ; in the female the cloaca remains open. We believe that the sexual glands, as soon as they are differentiated, throw a secretion into the circulation which acts on the sex tubes or channels; the secretion of the testis causes the male parts to grow and the female parts to atrophy; that of the ovary stimulates the female parts and restrains the male.

The human embryo, like all vertebrate embryos, is furnished at first with the basal parts of both sexes. It is usual, therefore, to suppose that we have descended from a hermaphrodite form—one in which the organs of both sexes were combined. This cannot be regarded as a good explanation, for although in a few rare cases an imperfect sexual gland has been found, which showed some resemblance to the structure of a testicle in one part and to an ovary in another, there is not a single case of a true testicle and a true ovary having been found in the same person. A true human hermaphrodite has not been seen. The explanation which best accounts for the presence of both male and female ducts in the embryo is the fact that the male has to be the father of daughters as well as of sons; for that reason he must have a representation of the parts necessary to the one sex as well as of the other. Similarly the mother must be capable of handing on sexual characters to her sons as well as to her daughters. Hence both sexes are necessarily supplied with the parts proper to each sex.

This statement is also true of the breasts; rudiments of these are present in both sexes at birth. When the human embryo is only a month old a ridge on the skin (the mammary ridge) is seen to extend along each side of its body from the armpits to the groins. Some months later the parts of these ridges which lie on the upper part of the thorax undergo a development and form the two mammæ or breasts, while the rest of the ridge atrophies and disappears. The breasts undergo a slight development before, and immediately after birth, and then remain in abeyance until marked changes occur in the sexual organs at puberty. At that age they remain small in the male, but in the female they grow rapidly, and take on their characteristic size and form.

One of the most important recent advances in our knowledge of the sexual glands is the discovery that they are double in their structure and function. They are composed not only of germinal tissue, which gives origin to the reproductive elements, but also of another tissue which is glandular in nature and supplies a substance to the various parts of the body by means of the circulating blood. On some parts of the body this substance has a most powerful influence, and stimulates growth. The secretion which issues from the ovary at puberty acts upon the latent breasts, and calls forth their growth in the female; the secretion of the sexual glands of the male has no such influence. There are numerous proofs of the truth of this statement. I need not relate the facts which medical men are well aware of; those who are familiar with unsexed domestic animals will need no further proof of the influence of the testicles in moulding the form of the body. At the end of each pregnancy a secretion derived from the genital parts of the mother, which acts on the breasts, leads them to increase in size and yield a secretion of milk. These facts are extremely important to us because they reveal the secret and yet simple manner in which nature works out the physical characters of our bodies.

The breasts must be reckoned as parts—secondary parts or characters—of our sexual system. The reader already knows that milk-giving glands appeared with the evolution of mammals. The thoracic position of the milk glands is also an old feature of the stock from which mankind arose, for in all monkeys and anthropoids we find only two mammæ, which occupy the same position as in man. In the ape embryo, as in the human, a mammary ridge is formed along each side of the body. In many mammals, such as the sow and bitch, mammæ are formed on the whole length of the mammary ridge—from armpit to groin. It occasionally happens in men and women that besides the usual pair of breasts, others may be formed just below or just above the normal breast glands. Rudiments of supernumerary mammæ and nipples are not rare; vestiges may be seen in one out of every twenty men or women. We may infer from these facts that the stock from which the ape-like mammals descended was one with breasts arranged along the length of the body as in the pig. The supernumerary nipples and mammæ which occasionally occur in man are revivals of characters belonging to a remote stage in the evolution of the mammalian stock.

At birth the boy and girl are much alike in appearance. It is true the boy has usually a stouter and heavier body and a larger head than the girl, yet it is only from the deeper parts that the sex can be told with certainty. At birth and even before birth, the sexual glands are influencing the development of the body. Professor Arthur Thomson, of Oxford, noted that in the fœtus of five months the pelvic bones of the two sexes were slightly different in shape. It is at puberty that the glandular influence becomes most marked. We have already seen how rapid the increase of stature is in girls from the twelfth to the fourteenth year, and in boys between fourteen and sixteen. It is at the period of puberty that the breasts of the female develop; at the same time the pelvis takes on its roomy character. The breadth in the lower part of the body becomes a marked feature in woman. The tops of the thigh-bones which articulate at the sides of the pelvis are pushed outwards and become relatively further apart than in the male. Hence when walking, women have to make rather a greater effort than men, for with each step the weight of her body has to be transferred across her wide pelvis from one thigh to the other. At puberty, too, the type of breathing changes; respiration becomes centred more in the upper than in the lower part of the chest. The thorax changes in form. The use of corsets tends to emphasize, even to a degree of distortion, the normal prominence of the upper part of the thorax of women, and at the same time, by constricting the waist, to bring into prominence the lateral projection of the pelvic part of the body. In all races and in both sexes, fashion is often the excuse for exaggerating the natural characters of the body.

In the boy's body it is another set of structures which are affected at puberty. About the sixteenth year we notice the face begins to change. The hair roots of the beard, which had up to then remained latent, are stimulated, and hairs begin to peer out on lips and cheek. The whole muscular system gains in size and strength; the bones of the skeleton become thicker and longer, to meet the increased strain of the muscles. The whole apparatus of mastication undergoes a change; the maxillæ and all the bones of the face increase in size and strength; the muscles of mastication extend their origin on the skull; the bony ridges, which give origin to these muscles, become more pronounced. The ridges which cross the forehead above the orbit are slowly developed, and become more massive and prominent than in the female. The nose assumes its adult form; its growth is often out of harmony with the rest of the face. The slender, child-like neck, which persists in women, begins to become stouter and thicker in young men. In some this increase in the growth and strength of the neck ceases soon after puberty. Such men retain to some degree the tapering neck and prominent occiput of the boy. In other men the thickness of the neck may continue to increase until the thirtieth year, so that the back of the head appears as if it had been pressed into their stout necks; the occiput, which projected in boyhood, disappears with the age changes of the neck. The heart and the lungs have to respond, in order to meet the increased needs of the muscular and bony systems. The chest expands, especially its lower part; and bit by bit we see the loose-jointed frame of the boy become the closely knit and filled-out body of the mature man. All these changes, we believe, are stimulated, and to some degree regulated, by a secretory mechanism seated in the sexual glands of the male.

One of the most marvellous changes in boys at puberty is the breaking of the voice. The reader is already familiar with the prominence to be seen and felt in the front of the neck, popularly known as "Adam's Apple." On this prominence the finger will distinguish the sharp keel-like projection of the chief cartilage of the larynx—the thyroid cartilage. A notch or hollow can be felt on its upper border, and just above the notch the hyoid bone, which moves with the tongue.

The lower border of the thyroid cartilage cannot be made out clearly with the finger, but about half an inch below it, the anterior hoop of the ring-like cartilage of the larynx —the cricoid—can be felt. Below the cricoid follow the cartilaginous hoops of the windpipe. Now the two vocal reeds or cords, which can be set vibrating with the breath, are fixed within the keel or prominence of the thyroid cartilage by their anterior ends, while their hinder ends are attached to two swivel-like cartilages which are set on the hinder and upper edge of the cricoid cartilage. When we are breathing naturally the vocal cords are drawn apart by special muscles, leaving a triangular interval—the glottis—between them. When we speak the cords are approximated and only a narrow chink separates them. The vocal cords can be tightened or slackened, thus altering the note of the voice. There are special muscles for every movement of the vocal cords. Although singers may not know a single one of these muscles, they can learn to use them, so as to produce what sequence of notes they will. When a boy reaches the age of puberty, all these structures of the larynx—the cartilages, the cords and the muscles, undergo a rapid growth; the boy's voice "breaks" and becomes hoarse and then manly. It is well known that this change can be prevented, for it was a custom in eastern countries to emasculate choir boys, in order to preserve their voices. In such cases the other sexual characters—the beard, the muscular development, the face, head, neck and body changes were also arrested. One other remarkable change occurred, the limbs, especially the legs, grew to a greater length than in the normal man. Eunuchs are much above the average stature, and they are apt to become fat, for there is no doubt that there is a relationship between the tendency to the deposition of fat, especially on the lower parts of the body, and the activity—or rather non-activity—of the sexual glands in men and women.

These influences of the sexual glands on the growth and form of the human body are of the greatest interest to scientific men, because they seem to afford a clue to the laws which regulate the shape of our bodies. Just as the activity of these glands leads to one set of bodily changes, so it happens, as their activity decreases and their influence is withdrawn, certain parts of the body undergo a further modification. In most women a decided change comes over their features about the fiftieth year. The female sexual glands are then undergoing a down-grade change. Some of these changes, such as the increased wrinkling of the skin and the deepening of natural furrows, are purely effects of age, but the increased prominence of the cheek bones, the more decided prominence of the supra-orbital ridges, the more massive angles of the jaw and the thickening of the neck, seem to depend on some other factor. There may be a tendency to a straggling growth of hair on the lips and cheeks, and a deepening in the tone of the voice. All these modifications appear to be a mild assertion of male characters—or perhaps it would be more correct to say of neutral or asexual characters, for both man and woman are modifications of a third individual which we may name the neuter or asexual. The withdrawal of the sexual secretion, which restrained the growth of certain parts and helped to preserve the attractions of young womanhood, seem to allow the natural forces of growth to reassert themselves. In men the function of the sexual organs persists to a late period in life, and hence we see no corresponding changes in the opposite sex.

It will be observed that of the two sexes, the male is the more specialized; the female the least. It is she who retains the characters of youth or of childhood—not only in the face, neck and body, to a much greater degree than the male, but women have also the good fortune to preserve to a greater extent the power of enjoyment of life which is natural to the child. The male has another destiny; his brute strength and his courage are bought with a price.

It has already been remarked that there is a greater tendency on the part of African races, than is the case with European races, to retain certain child-like characters. This is also true as regards certain sexual characters. The African male, as a rule, shows only a slight growth of hair on the lips and cheeks at puberty. The beard does not sharply distinguish the male from the female. Nor is the female pelvis of the African woman so roomy and capacious as that of European women. Indeed in primitive races there is a tendency for the sexes to approach each other in the pelvic characters.

CHAPTER XI

RACIAL CHARACTERS OF THE BODY

If I were to declare openly that this chapter is nothing more or less than an attempt to expound the "Principles of Physical Anthropology," I fear that I should turn my readers away with the declaration that they do not wish to know anything of a subject which has such a forbidding title. The subject, however, is really not uninteresting, and the reader will be surprised to discover he knows much more of it than he is aware. Modern commerce and our world-wide enterprise have brought all the races of the earth as visitors to our shores. We see them plentifully in our great seaports, and even in the most remote country villages we have now and then an opportunity of making their acquaintance. It is on those occasions we discover that we do know something of Anthropology—or Ethnology as it is sometimes named. How otherwise did we recognize that the stranger who drew the eyes of the village on him was a Chinaman, a Red Indian or a Negro? If, however, we are asked how we knew, we find we are not quite certain, and that our knowledge of the subject is rather subconscious. Those who study the bodily characters of the varieties of mankind are seeking to make this subconscious knowledge into a system of well-defined facts to which the name of Physical Anthropology is given. We collect these facts not only to ascertain how one race differs from another in structure of body, but we have a larger aim in view, we wish to know how and when the earth became populated with a diverse humanity.

It is always well to begin our study at home. When we see a regiment in full dress march past we recognize it as the "Suffolks," the "Gordons," the "Connaughts," or the "Welsh Fusiliers," as the case may be. When, however, the soldiers file silently past, dressed alike in a fighting uniform, without a number or a badge, can we distinguish the nationality? I doubt if one could, and I hold the opinion that, however many racial stocks have been planted from time to time within the bounds of Britain, the condition at the present day is such that we cannot tell—except from speech, temperament or local mannerisms—whether a given batch of men are English, Scotch, Welsh or Irish. It is possible that the professed anthropologist, by making a series of measurements as regards height, proportion, and shape of head, and other observations on colour of skin, and eyes and hair, could tell the part of the country from which each batch came. Our difficulty lies in the fact that in every county we see that there are many types of body and face and many shades in the colour of hair and skin. It is true that in some counties certain types prevail and other types are uncommon, while in other counties these same types occur in an opposite proportion. At the present time there is a tendency to suppose that a pure race is made up of individuals having the same form of body, and that, if within the bounds of a country or of a county several types are found, there has been a mixture of races in that country or county in past times. Such an opinion seems quite reasonable, especially when we remember how many invading peoples have settled in Britain from first to last. When, however, we begin to survey even the purest human races we find within their communities just as great a variety of bodily form as is to be seen in any part of Britain. Nay, I am quite certain that the reader can recall families in which some were tall and some short, some dark and some fair, some with a narrow face and some with a wide face. The existence of numerous types and varieties inside even the purest race is a most important fact, for it is easy to see how the characters of the race might be changed if certain types flourished and increased in numbers, while other types were gradually repressed and ultimately disappeared. So far as we know there is no selection of any special type in progress in Britain.

If, however, we were to pick a man from the streets of Strassburg, and set him side by side with the first man we met in Nottingham, we should probably see the two chief types of mankind in Western Europe. We have nothing to do with the national spirit, the speech, the hairdressing and tailoring which mark the one off from the other; these are of the greatest importance, but they are outside the bounds of physical anthropology. The colour of hair and complexion of skin, hue of eye, may be the same in these two individuals drawn from towns so far apart; their faces may be of the same type; it is probable, however, that the Englishman's face is the longer and narrower. Their stature may be the same—possibly the Englishman is the taller by about half an inch, but not heavier. The form of head, however, is totally different. When we take the length and breadth of the Englishman's head we shall probably find that its breadth is between seventy-four and seventy-six per cent. of its length, or if we wish to give our knowledge a learned turn we say that his "cephalic index" is between seventy-four and seventy-six. In the Strassburger's head the cephalic index is probably between eighty and eighty-two. When we look at his head in profile it appears as if it had been compressed from back to front, so that the width of the head has been increased and the brain pushed forwards, thus coming to occupy a more anterior position above and in front of the ears. The height of the head is increased. The Englishman's head has been compressed from side to side and rather flattened on the top, so that it does not appear to be so high as the German head. We find then that the best mark to distinguish the typical Englishman from the typical German is the shape of the head. It must not be forgotten, however, that in Nottingham, as in Strassburg, there are all forms of head, but the rounded type prevails in the one and the long type in the other. It is possible, but very unlikely, that two individuals, selected by chance, may have the same types of head.

If we estimate the capacity of the skull in these two selected types of man, we shall probably find that in size of brain chamber they are about equal, each containing from 1,480 to 1,500 cubic centimetres of brain. When, however, the reader asks me why the head is long in one and round in the other, I must confess that no satisfactory answer can be given to the question at the present time. We know, however, that the head is artificially and grossly distorted in infancy by many races of mankind—indeed the custom was once common in Europe—without producing any marked mental change. The brain also suffers a change in shape in those cases of distortion, but travellers have noted that the men with the altered heads are just as intelligent as those whose heads have escaped constriction. The brain seems to work as well in one shape of skull as in another. As a matter of daily experience we have no reason to think that the round-headed man is more capable than the long-headed, and yet when we come to trace the history of long-headed races in Europe we meet with facts which give matter for thought.

If we make a survey of modern Europe we find the long-headed races scattered along her western shores—in Norway, in Britain, in those parts of Denmark, Germany and Holland which flank the North Sea ; in Spain, and to a less degree in parts of France and Italy. Round-headed peoples dominate the great central region of Europe. If, however, we go back 5,000 years and examine the graves of that remote period, we obtain a different picture of head and racial distribution in Europe. The German, the Swiss, the French graves of that time contain the bones of men who were of the long-headed type ; we must suppose them to represent the people of the country at that period. We know from history and from tradition that waves of round-headed races have pressed westwards and southwards in Europe, and all the evidence goes to show that these waves issued from that part of Europe now included in the Russian Empire. We know, too, that an advance guard of the round-head invasion reached our shores some 4,000 years ago, when bronze was the metal employed by civilized races. Graves of these people have been found from Yorkshire to Kent, and in Scotland. They were conquerors and yet they could not save their head-form; in the course of generations the round head merged in the long, not perhaps without some effect on our modern head-form. We have every reason to think, then, that in Europe the round head is the prevailing type. Indeed, had it not been for the discovery of America and of Australia the long-headed type of European would have been sparsely represented in the modern world.

We now set out to enquire which of these two types of head, the round or the long, is the older or more primitive. We turn first to the anthropoid skull to see in which mould it is cast. In the adults we find that the shape of the essential part of the skull—the part which contains the brain—is masked by a great bony framework which was formed during the years of youth to give attachment to the muscles of mastication. We must, therefore, measure the skulls of the young, and in them we find the breadth amounts to eighty per cent. or more of the length of the skull. The anthropoids are round-headed, especially the orangs. When we look more closely we see that the roundness of the anthropoid head is altogether different in character from the roundness of the modern European head. We see at once that the anthropoid's skull is wide, because the width is increased at the price of height; it gives the impression of having been compressed from above downwards into a bun-shaped form, the width being thus increased and not the length. The apparent compression of the human skull is rather from behind forwards as in round-headed races of men, or from side to side, as in long-headed races. Thus we cannot say that the round type of human head is more anthropoid than the long one.

When, however, we examine the skulls of the most ancient men yet discovered, the evidence is very definite; all of them have the long form of head. In the oldest and most primitive type yet found—the fossil man of Java—the breadth of the skull is seventy-two or seventy-three per cent. of the length; he is long-headed. We note in this skull, however, a very remarkable feature—it is flattened or compressed from crown to base, as we have seen to be the case in anthropoid skulls. In another very ancient skull from Gibraltar we notice this anthropoid character and also that the breadth is seventy-four per cent. of the length. In the Neanderthal race, which lived in Europe during the glacial period, the head is also of the long type, and indeed the length of their skulls is much above the modern average. The Cro-Magnon race, which came long after the Neanderthal and yet were inhabitants of France before the glacial period had closed, were remarkably long-headed. The oldest man yet discovcred in England—the Galley Hill man, who also apparently belongs to the glacial period—had a remarkably narrow and long head; the breadth is only sixty-nine per cent. of its length. From all these facts we must conclude that the long head is the older type. Indeed, all the evidence points to the round form of skull we have seen in the citizen of Strassburg as a comparatively recent product in the evolution of human races. The evolution of the form of the human skull seems to have taken place in the following order. The anthropoid skull, short, wide, flat, seems to be the oldest form. In the early human stock it became long, moderately wide, and flattened; later it became long, narrow, and high, and lastly short, wide, and high.

We have been comparing opposite types of head-form, and we now propose to contrast the most widely divergent types of mankind. As one of these we select again the man from Strassburg, premising that he is of the short-headed or brachycephalic type, with blonde hair, blue eyes, and a fair clear skin. Beside him we propose to place, for purposes of contrast, a negro from the heart of Africa. Here I would beg of the reader to break away from the common habit of speaking and thinking of various races as high and low. When we meet the native of the Congo in his home we find that he does not share our opinion that we are of a superior race and type; indeed, his candid opinion is the reverse. High and low refers to civilization; it does not refer to the human body. When we have placed a Central European and a Central African side by side, we see before us the end stems of the two most divergent branches of humanity. They are equally old in type, and we may truthfully say equally specialized. We believe they have arisen from a common stock, but that must be a million of years ago or more. The mere diversity of their bodily features indicates an evolutionary period of great length. We note the difference in their head-form; the negro has a long, narrow head; its cranial capacity is less, and on the average the brain is simpler in its pattern. It is the difference in colour that impresses us most. In the negro the skin and eyes are laden with black pigment, which is being constantly absorbed and constantly renewed. Even the deeper parts of the body show scattered patches of pigment. In the Central European there are pigment granules in the skin, but the skin must be cut in fine sections and examined with the microscope before they are plainly visible. The contrast in colour in the two types is so great that it seems scarcely credible that we are dealing with the same species of being. Indeed, there are many who maintain that they belong to different species. Yet we know that intermixture of these two types produces children which in turn are fertile for generation after generation.

When, too, we cross from Central Europe to Central Africa, we see that these two extreme types of mankind are linked together by all the intervening shades between fair and dark. In Southern Europe the skin and hair become more pigmented ; in Northern Africa the skin is dark brown or black. Whenever we find an intermediate series which carries us from one extreme to the other, we believe that those extremes may have arisen from a common stock. We see, too, how the inhabitants of the same country or even of the same parish, may show many shades of pigmentation —but for each country there is a certain average, and the variation in shade is bounded by definite limits. When we wish to explain why the Central European is fair and the Central African is black, we are brought at once to a dead stop by our ignorance. We do not know what service pigment performs in the human body. We cannot suppose it to be a useless substance. It is true that it is most developed in those who live in hot climates, yet the ancient Tasmanians, the natives of a very temperate climate, were black. There is no definite proof that negroes become less black in temperate countries, nor that fair men become more pigmented in tropical lands. Yet it seems most reasonable to suppose that the pigment of the skin does protect the body from certain rays of the sun.

Anthropologists have always presumed that the primitive human stock must have been dark-skinned. Certainly the degree of pigmentation seen amongst the great anthropoids lends support to this theory. The gorilla is black; there are various races or varieties of chimpanzee, and all of them show a degree of black pigmentation. In one variety the skin becomes totally black; in another, pigmentation of the face and of other parts is delayed until late in life; in others the face never becomes absolutely black. The skin of the orang is also deeply pigmented, but the black granules are masked by the presence of a red element. The evidence supplied by anthropoids points to a common stock with dark pigmented skins. It is very possible, however, that in the progress of evolution, the degree of pigmentation has somewhat increased in the pure negro races, while in the Central European it has become greatly diminished. One is led to form such an opinion from the skin colour of the natives of Australia. They have so many primitive features in the structure of their bodies that it is also possible that their skin colour is likewise primitive. Their skins are not so deeply pigmented as in the typical negro. On the whole, the evidence points to the stock from which human races have arisen as having had brown pigmented skins. The very black African and very fair European races may represent comparatively recent products in the evolution of modern races.

We must return to the consideration of the African and European types of mankind now standing before us. We shall admit, I think, that in character of skull and of brain, and in colour of skin, the negro shows the older type, but in the character of his hair this is not so. The woolly hair, coiled naturally into little isolated locks, is unlike the hair of ape or man. It is a feature of the negro or negroid races, and was evolved with them. The straight black or wavy brown hair of the European appears to be more primitive in character. There are two other features of the negro's face which appear to be specializations or departures from the primitive type. The thick everted lips are very different from the thin straight lips of the anthropoid apes. The thin European lips seem a more primitive type, and yet when sections are made of the lips of Europeans and Africans certain features are seen which make us hesitate to endorse this opinion. Then, again, there are the characters of the forehead. It is true that in the West Coast of Africa we meet natives with prominent supraorbital ridges and receding foreheads. In the typical African negro this is not the case ; the forehead as a rule is high, narrow, often prominent or bulging, and the supraorbital ridges are moderately or slightly developed—distinctly less prominent than in the European. There is not a shadow of doubt that the stock from which modern man is descended had great supraorbital ridges. They are still to be found in a fairly primitive form in native Australians, but to see them at their best one must examine the skulls of those ancient Europeans—the Neanderthal race. In the gorilla especially, and also in the chimpanzee, these supraorbital ridges form prominent bony ledges or shelves above their sunken eyes. The typical negro is destitute of great supraorbital ridges, which are primitive features.

When we compare the negro and European nose it may be a question as to which is the more primitive. Neither the one nor the other is like the nose of the anthropoid, and yet of the two, the sharp, narrow, prominent nose of the European, with its high bridge and compressed wings, must be admitted to be the more specialized type. If, however, we leave the Congo Valley and make our way to

Egypt along the Valley of the Nile, we shall meet with various negro tribes in whom the nose is narrow and prominent and almost European in shape.

We have reason to believe that the shape of the nose does depend to a considerable degree on the development of the teeth and jaws. A long, prominent and narrow nose is usually part of a face in which the palate is narrow or contracted and in which the jaws have grown in length rather than in width and strength. In the ancient inhabitants of Europe we find the jaws and teeth well and regularly developed and the nose of fair width. In modern Europeans, especially in those with long heads, we find a tendency to an irregular development of the jaws and to an elongation and narrowing of the face, with the result that the nose also is rendered sharper and more prominent. The jaws and cheeks have retreated and left the nose as a narrow prominent organ on the face of the typical European. In Central Africa we find other tendencies at work; the teeth are big, white, and regularly set in well-developed jaws. The face is broad rather than long. The jaws may be so well grown as actually to give the individual the appearance of having a muzzle. The nose is correspondingly flat and wide. In brief, I conceive it possible that the nose of the negro might assume a European form were his teeth and jaws to undergo those changes which are apparently occurring amongst the civilized peoples of Europe and America.

There are other features of the body we ought to contrast in the European and African—the longer forearm and leg of the latter, the absence of calf and longer heel, the different type of ear, but enough has been said to give some idea of the chief bodily features in which one race of mankind differs from another.

In Eastern Asia we find another distinctive type of modern man. We may take the Chinaman as a representative and place him with the Central European for comparison. They are both short-headed or brachycephalic, but their heads are essentially different in shape. The Mongolian head is really round or ball-shaped. The skin is pigmented—less so than in negro races, but more so than in European. The hair is strong, lank and black. The stature is short—perhaps two inches less than in the European, the shortening being due not to a diminution in length of trunk so much as to a shortening of the legs In size of brain there is nothing to choose between the two types. The chief difference lies in the face. The cheek bones are prominent, the teeth good, and the jaws strong in the Chinaman, but we note at once that the supraorbital ridges are less developed than in the European. In this the Mongol resembles the negro, but his forehead is wide, not narrow as in the negro. The essential Mongolian feature is the nose—its low sunken bridge over which one eye can almost see its neighbour. With the depression of the nose a peculiar fold of skin—the epicanthic fold—is drawn like a curtain above the inner angle of the eye. The eyes seem set at an oblique angle, a feature which Chinese artists love to emphasize. The Mongolian face, when compared with the European, is remarkably flat and shield-like. The forehead, the prominent cheek bones, the sunken nose and well-developed jaws all take a part in forming this facial plateau.

Thus we find contrasted types of man have been evolved at divergent points or centres of the old world—in Europe, in Africa, in Asia. When we remember that the skulls and limb bones of the inhabitants of Egypt have changed remarkably little during 5,000 years we must conclude that evolution amongst human races does not proceed quickly. One finds the same form of skull among Englishmen of to-day, as occurred in the men who lived in Britain many thousands of years ago. If then, we believe in evolution, it becomes evident that the well marked differences which characterize the races of Europe, Asia, and Africa, must be the result of a very long period of time.

All the factors which have operated to produce characteristic racial features we do not know, but there is one with which every one is familiar. If the reader has had the fortune to be born and bred in the country he will remember perhaps that as a boy he was prepared to defend the claims of his fellow-parishioners against those of neighbouring parishes. In after years when he had left his home and taken up his abode in a strange town or country, he has probably observed that a man of his own county or town has some indefinite claim upon him over another man. He is inclined to trust a member of his own nationality rather than that of another. The feeling or prejudice, which subconsciously influences him, is the backbone of nationality; it is the moving force which welds together a community. It is that inborn feeling to which the name of race prejudice or race caste has been given. That is the feeling expressed from the politician's or economist's point of view, but it has also a meaning for the biologist. The same mental trait, which we see operating in a village, and which we see binding a scattered people into a nation, is, I think, the innate mental character which binds the animals of one species or of one variety together, and it nourishes and strengthens the community which it binds together, and at the same time sets that community at enmity with every other community which lies outside its borders. In such communities new physical types may be evolved, and we can see how a sense of caste may keep the type pure, and how pride of race may lead to the expansion of territory and the propagation of a racial type.

The sense of caste or race seems to have played a great part in the separation of mankind into the numerous races which are now scattered over the earth. Unless it be present no community or nation could extend its borders without losing its individuality in neighbouring peoples. The Portuguese settlements in Africa and in the far East during the sixteenth century offer us an example in point. So little was their sense of race developed that in a few generations the blood of the original settlers was swamped by the blood of native races. Anglo-Saxons have succeeded as colonists, and not the least element of their success is due to their highly developed sense of race. Cosmopolitanism is a condition in which the prejudices relating to race have been eradicated.

CHAPTER XII

BODILY FEATURES AS INDEXES OF MENTAL CHARACTER

There is a general consensus of opinion that those who pretend to read character from the shape of the head—phrenologists—and from the lines of the hand—palmists—boast of a knowledge they do not actually possess. In the course of this chapter we shall see what grounds there are for supposing that the head or hand can guide us to the character of their owner. There is one part of the body, however, we are constantly appealing to, and ever drawing inferences from—sometimes rightly, sometimes wrongly, and that is the face. Most of us believe that the face may show what the mind is really trying to hide. It is not the bony ground-work of the face that guides us, it is the expression we note. Now the skin of the face has been furnished with a special means for reflecting our mental states. It is under the control of an elaborate system of muscles, regulated by a special nerve—the facial or seventh cranial nerve. Its vessels are most delicately controlled by the sympathetic nerve system over which the will has no power. The sympathetic system responds to our emotions until experience and years have blunted the delicacy of the adjustment. In anger or in fright the vessels react to the nerve centres which control them; they become restricted in anger, giving the face a blanched or livid appearance; in shame or in joy the vessels dilate and our faces blush or flush. The faces of men who are exposed to all kinds of weather turn ruddy in the course of years, because the vaso-motor or vessel-regulating mechanism becomes exhausted.

As a means of expression the vaso-motor mechanism is a minor one; the facial muscles form the chief. A pair of these muscles—the frontal—form a sheet beneath the skin of the forehead; they can lift up the eyebrows, puckering the skin into folds which cross the brow. As long as the skin retains its youthful elasticity, and especially in those who live placid lives, free from pain or care, the wrinkles disappear as soon as the muscles cease to strain, but in most men by the age of forty, the wrinkles on the forehead have become permanent marks. The action of the frontal muscles can be reversed. If the skin of the eyebrows is fixed by bringing into action the muscle which encircles each orbit, the frontal muscles then exert their power on the scalp and move it forward. Another pair—the occipital—are attached to the scalp behind and act as opponents in moving the scalp back. Many people lose, or never acquire, the power of voluntarily throwing these muscles into action. The muscles of the scalp are especially well developed in apes, and every one must have noted how freely these animals can use them as a means of threatening their foes or welcoming their friends.

The eyes are full of expression and yet as the portrait painter knows well—it is difficult to analyse the various points on which we form our judgment. In some, the eyes seem large, in others small, but the difference is really due to the amount exposed by the lids, for as regards actual size our eyes are the least variable structures of our body. The upper lid is the real movable curtain of the eye. A special muscle within the orbit lifts it up and keeps it up so long as we are awake; in sleep it passes out of action. In alert men this muscle is strenuously in action. The upper eyelid is also provided with an involuntary muscle, which, like the arteries of the face, is regulated by the sympathetic system and alters the lid with each change in the emotional state. In fright our eyes seem to start from our heads, so vigorously do these involuntary muscles act. Soon after adult life is reached the eyelids lose their delicate outlines and the skin round the orbits becomes wrinkled and often loose. The wrinkling is due to the orbital muscle which forms a loop-shaped sheet of muscle round each orbit. The muscle is primarily for closing the lids and protecting the eyes; we feel it come into action when we pass from the shade into the strong sunlight. It draws the eyebrows over the eyes and thus shades them. It will be observed that the skin on the cheek and temple, and on the outer side of the eyes is thrown into radiating folds or wrinkles when the orbital muscles are in action. As the skin loses its elasticity these wrinkles become permanent and form "crow's feet."

As a means of expression the muscles of the nose are not of importance. On the wing of the nose are found very reduced representatives of those strong and active muscles which dilate and close the nostrils of the winded horse. We speak of "turning our noses up"; we have no muscles specially provided for this purpose—but there is on each side a muscle with the unsatisfactory name of compressor nasi, which has the power of drawing the adjacent skin towards the ridge of the nose—a means of expressing contempt.

The most elaborate mechanism for expression is found in connexion with the lips and mouth. The lips are used in speech and change with every form of emotion. As one may guess from the manifold movements of the lips, the arrangement of the muscles within them—the orbicular musculature of the mouth—is most complex. Special muscles are provided for lifting the upper lip and depressing the lower; each angle of the mouth has its "levator" and its "depressor." In some, the levator is the dominating muscle and the corners of the mouth are drawn upwards into a suggested smile, just as in others the corners droop under the influence of the depressor muscles. While the skin is loosely attached on the face and cheeks, over the lips and in their neighbourhood it is closely bound down. The line which marks the junction of the fixed labial skin with the free skin of the cheeks corresponds to a furrow which passes obliquely downwards from each side of the nose until it passes beyond and outside the angles of the mouth, thus separating the upper lip from the cheek. These naso-labial folds often deepen with age, becoming very marked in some people. They are caused by the muscles which act on the upper lip; in laughing, for instance, the curtain-like upper lip is drawn, partly beneath the skin of the cheeks along the lines of the right and left naso-labial folds. With age the lips invariably lose their sharp outlines and their elasticity; in some they become drawn and tight under the continual contraction of the orbicular muscle situated within them; in others the muscle becomes relaxed and the mouth becomes loose and partly open or the lower lip hangs. The skin over the chin has a curious muscle which acts on it, sometimes named the "shaving" muscle, as it is employed to steady the skin of the chin against the razor. Its real use seems to consist in removing food from the recess behind the lower lip. The muscles of the cheek—the buccinator muscles—so called because they are seen in action in the puffed-out cheeks of the trumpeter, are also used in mastication, to place the food between the chewing crowns of the teeth. The muscles of the lips and cheek are employed in speech as well as in expression.

A wide sheet of the facial musculature—the platysma myoides—extends into the subcutaneous tissue of the neck. Under normal circumstances this muscle acts on the mouth and jaw, drawing them downwards and backwards. When an effort is made with teeth clenched and all the muscles of the body straining, the action of the platysma is reversed; its fixed point is in the face, and the muscle stretches and tightens the skin of the neck. The significance of this action is unknown. The platysma is the remains of a system of musculature which forms a complete sheet under the skin of the trunk of many mammals. It endows the skin with mobility. Every one knows how the horse can twitch the summer flies from its sides. In man and the anthropoid apes the muscles of the face and neck are all that remains of a great sheet, which in some animals is seen to be spread under the skin of the whole trunk.

The facial muscles of man are remarkable for their degree of differentiation and for their relatively small size. The great anthropoids have really the same muscles but have them somewhat differently arranged and somewhat less distinctly separated from one another. In the gibbon and monkeys of the old and new worlds the facial system becomes still simpler and at the same time more robust. It is a remarkable fact that the facial muscles of primates keep pace in their evolution with the brain; as the convolutions increase in number and capacity, the muscles of the face become smaller and more finely differentiated. The study of anatomy therefore supports the experience of our every-day life that much can be learned of mental character and capacity from the muscles of the face. It is clear that they are evolved as the servants of the brain. The human brain, however, has the power of mastering and masking true feelings, and hence it is also true that a smiling face may mask a sad heart.

The story of the evolution of the muscles of the face is a very wonderful one. It has already been said that the whole of the facial system is supplied by the seventh cranial nerve. In fishes and lower vertebrates the seventh is the nerve of the second or hyoid branchial arch, supplying the muscles of that arch; in the human embryo the nerve lies within the hyoid arch. It is from this arch that the gill-cover and its muscles are developed in fishes. Now it is a remarkable thing that the muscles of the face should be supplied by the nerve of the gill-cover arch and still more remarkable that the muscles of the face should first appear in, and be produced from this arch. Arising over the side of the arch they spread out under the skin of the face and take up their final position round the eyes, nose, mouth and ear. All the links in the chain of evolution we do not yet know, but we can only explain the nerve supply and origin of the facial muscles by supposing that they have been modified somehow from the actively moving respiratory gill-cover of fishes. It is worthy of note that when we are winded we do bring the platysma of our necks actively into use during forced respirations.

The external ear also arises in connexion with the branchial system. The ear passage represents the upper end of the first cleft and the ear is developed round it from a series of outgrowths. The muscles which move it are derived from the same sheet as the muscles of expression. In man these muscles are small, often vestigial. Besides very minute muscles which are situated on the ear itself there are three muscles which act on it as a whole —one which can pull it upwards, another forwards and a third backwards. In a few individuals these muscles may actually move the ear at will but they cannot really be called muscles of expression in man. In the great anthropoids these muscles are as much reduced as in man; in the orang they are even more so, for in that animal the outer ear is of very small size and closely applied to the head. In monkeys the muscles are larger and the ear can be moved, but not with that flexibility which is characteristic of such animals as the dog and horse; in which the ears are truly organs of expression as well as of hearing. When a monkey is angry it draws its ears backwards.

I am not aware of any one having studied the external ear as a clue to character, nor is there any fact which leads us to suppose such a study would be profitable. On the other hand it has been alleged that the ear may serve as an index to that type of man who is regarded as a "degenerate," an individual who is lacking in self-control and who is inclined to sacrifice the good of the community to selfish and evil passions. Certain features, such as abnormal crumpling up or infolding of the ear, and the absence of a lobule have been supposed to indicate such a tendency. The evidence on the whole is against the theory that an inferior nature is stamped by certain traits of the ear or any other part of the body, but an enquiry into this matter is attended with great difficulty owing to the extraordinary variability of the outer ear.

It is a remarkable fact that the outer ear of the great anthropoids and man are similar in type. In all of them the ear has lost its tip or point; only a remnant may be seen towards the upper part of the posterior border on the inturned margin of the ear. There is a distinct sexual difference; the ears of women are smaller and more folded than those of men and the lobule is usually larger. There is an age change; after fifty the ear begins to enlarge. The ear also varies with race, one could tell a Bushman by his small ears, with the hinder margins curved over to form a wide welt. In other races the ears are large and project from the sides of the head, as is invariably the case in the chimpanzee. Indeed it is possible in every community to see some individuals who in type of ear recall the reduced form seen in the orang, some the large outstanding ear of the chimpanzee, and some the medium sized ears of the gorilla closely appressed to the head. The degeneration of the external ear in man and anthropoids is another result of the upright posture; they turn their heads, in place of their ears, in the direction from which a sound appears to come.

We have already seen that there is no correspondence between the functions of the various parts of the brain, so far as we yet know them and the overlying parts of the head to which phrenologists have assigned definite functions (p. 32). It is possible, however, that certain features of the head may be associated with definite mental tendencies. Every one of us has a difficulty in believing that intellectual ability can be associated with a receding forehead, yet the experience of daily life convinces most of us that the forehead is a most unreliable sign. Strongly marked eyebrow ridges are usually significant of energy and strength, and one can understand such an associationship, for beetling brows are usually a sign of muscular development. The chin is another feature which also seems significant of character; a man with a pronounced chin is usually also one of determination. The chin is sometimes defined as a character of man; rightly it should be regarded as a character of modern man. It has already been pointed out that the mandible is made up of two parts—a part for carrying the roots of the teeth—the alveolar part—and a part which forms the frame-work of the floor of the mouth. Now in primitive races the teeth are large and so is the alveolar part of the mandible; it actually projects beyond the chin, which is then said to be receding. If we supposed that the teeth were to become reduced in size and perhaps in number, and there are good grounds for supposing civilization has produced this effect, the alveolar part of the jaw will recede and leave the chin prominent. Hence the chin is never well marked in primitive races with large teeth and mouths—such as the natives of Australia, of Africa and of New Guinea. There is probably also a positive growth of the chin forwards in connexion with the muscles of the tongue and of the floor of the mouth. We thus see that a prominent chin marks as it were a step in evolution, and may indicate a special mental trait—such as determination.

We come now to deal with the hand, which has been exploited by one class of men as a guide to human character and extolled by another class as the most remarkable of man's characters. The hand is beyond doubt a very wonderful mechanism, but it is not necessary to remind the reader that the hand is only the passive instrument of that much more marvellous mechanism—the human brain. Professor Klaatsch is perfectly right when he maintains that the human hand is modelled on a most primitive and antique type. It retains the five digits of the earliest of mammals; even in some of the lowest of these the first digit is modified to a thumb. The anatomical differences between the hand of man and of the gorilla are really not great ones. As regards function, that is a different matter; the hand of the gorilla is heavy and clumsy because its chief function is to support the weight of the body during progression. In the chimpanzee and orang the palm and fingers are very long and narrow; they are capable of grasping and supporting the animal from the thickest branches. In man the hands have been set free from the purposes of locomotion and have become specialized as manipulative instruments. In swinging from branch to branch the anthropoids use their fingers as hooks; their thumbs serve only for the minor purposes of grasping and lifting small objects. Hence in all the great anthropoids the thumbs are small; in the orang they are so reduced that one may say that they are vestigial. The nail is often absent from the thumb of the orang so small is the last phalanx or joint. The great size of the human thumb will be apparent when it is contrasted with the middle digit. In man it usually measures 68 to 70 per cent. of the length of the middle digit; in the gorilla, which has the most human-like hand, it is equal to 43 per cent. of the length of the middle digit. The thumb of man is characterized by its highly developed musculature. The special flexor or bender of the thumb is a large and distinct muscle; in anthropoids it is so reduced as to be almost a vestige; in the gibbon it is also large but it is conjoined with the flexor of the index finger. In man the great flexor of the thumb is undergoing a progressive change; in the great anthropoids a retrogressive one.

There is also a new extensor muscle on the human thumb. There are three segments for the thumb, each of which has an extensor muscle in man. In all apes the middle segment has no extensor, with one important exception. In a small proportion of gorillas we find the rudiment of such a muscle; it is being evolved as a slip which is separating off from the extensor muscle of the segment or joint at the base of the thumb. The human hand then has in a recent state of evolution undergone certain changes, especially as regards the size and strength of the thumb, but in its essential design and in the number of its parts it is really a very old structure. A vestige of a former bone is seen in the wrist of man. Between the upper and lower rows of carpal bones of the wrists there is seen a central bone in the wrists of monkeys. The central bone is also present in the orang and it appears during the development of the human hand but it soon disappears. Traces of it can be frequently seen. A similar fate has overtaken this bone in gorillas and chimpanzees.

The long and narrow hand is often regarded as showing breeding when it occurs in mankind; we have seen that the orang and chimpanzee have hands of this nature. When, too, we come to study the lines of the palm—the lines to which astrological names have been applied since ancient days—we find that man is not peculiar. When the thumb is flexed on the palm a fold appears between the ball of the thumb and the rest of the palm ; the crease which marks the site of the fold is known as the "line of life." If the thumb and little finger are brought in contact, another fold appears on the centre of the palm running from the wrist towards the base of the middle finger ; it is the "line of Fate." When the fingers are flexed two folds appear across the palm ; the one nearest the base of the fingers is the "line of the Heart ;" the further transverse line is that of the "Head ;" both it will be observed are foldings of the skin of the palm in front of the knuckle joints. These creases or lines in the skin are exactly of the same nature as the folds which appear in front of the elbows and behind the knees in the sleeves and trousers of the sedentary student. They indicate the manner in which the thumb and fingers are flexed on the palm. Palmistry is really a childish game of make-believe. It must not be forgotten that monkeys which we count quite low in the primate scale have the "girdle of Venus" —and well marked "marriage lines" ; the lines of our hands are old-time hieroglyphics. Those on the soles of our feet are also interesting. They are arranged in a similar manner to those of the palm, but only vestiges of them are left on the human feet at birth owing to the great modification which man's foot has passed through, to make it suitable as an instrument of plantigrade progression.

We have already seen that the lines of the palm of the hand are formed exactly where the skin and tissues are folded when the fingers are flexed and when an object such as a cricket ball is grasped. The lines appear on the palm of the hand of the fœtus, exactly right in position and direction, before hand movements have actually occurred. That is a very remarkable fact. It could be explained if we suppose that such folds were first produced by use and in course of time such adaptations have become inherited. What are the means by which such functional characters become inherited? The fœtus in which we see those lines on the palm has already the ova or spermatozoa set aside for another generation; we cannot conceive a means by which the movements of the hand can influence the ova which are to give rise to the next generation. The manner in which acquired characters become hereditary is a great and unexplained puzzle. We must believe, however, that under certain circumstances "acquired" characters are inherited, otherwise how shall we explain the appearance of the flexion lines on the palm before the hand is actually in use?

If we cannot use the lines of the palm as guides to the future we can certainly establish the identity of an individual from the patterns made by the papillæ on the finger-tips. The papillæ of the palm and flexor surfaces of the fingers are prominent and arranged in lines with the furrows between the lines. As Professor Hepburn has shown, the papillæ and furrows are designed to give security of grasp. On the summit of each papilla opens the duct of a sweat gland to keep the skin moist and so prevent objects from slipping from the grasp. On the fleshy bulbous end of each digit it will be seen that the rows of papillæ form definite patterns. There are three common forms (1) a loop, (2) an arch, (3) a spiral or whorl. Forms are also seen in which these three types are more or less combined. If the reader will glance at his fingers, examining the digits from thumb to little finger, first of the right hand, then of the left, examples of all three forms will probably be observed, but he will not find anywhere in the world another individual who shows these forms occurring in exactly the same sequence. The patterns can be used as letters of an alphabet, and any one who has left his finger prints has left an unmistakable signature behind him. I look on my own fingers and see that the patterns come in the following order :—

	Thumb.	Fore-finger.	Middle-finger.	Ring-finger.	Little-finger.
Right Hand	loop.	arch.	loop.	loop.	loop.
Left Hand	loop.	arch.	loop.	loop.	loop.

On the fingers of anthropoids the whorl is the predominant type, while in monkeys the patterns are of an oval and more primitive form.

On the palm of the human hand remnants of certain primitive patterns may be seen. One of these is situated on the hypo-thenar eminence—the elevation on the palm opposite the ball of the thumb. Traces of three patterns may be found on the palm at the roots of the fingers. These patterns on the palm are traces of certain elevations or pads which are well seen in the palm of the monkey's hand.

CHAPTER XIII

SKIN, HAIR, AND SENSE ORGANS OF THE HUMAN BODY

The reader may think that I am grouping together very dissimilar structures in this chapter. The eye, the ear, the nose, the hair, the skin, the nails, the teeth, sweat, milk and sebaceous glands, although very different in appearance and function, have one character in common; all are developed from the covering or epidermis of the embryo. We have been in the habit from childhood of thinking of the skin as merely a covering or clothing for the body. When, however, we study the skin or surface covering of even the lowest animal we find it is triple in its function: it is a covering, a sense organ, and a gland. We have already seen how a strip of the embryonic covering is modified and enclosed to form the beginning of the spinal cord and brain. Along the gums a fold of the skin grows down to provide the enamel crowns of the teeth. The teeth are really incrustations formed round skin papillæ. During the fourth and fifth months sprouts of the epithelial cells of the surface layer grow into the true skin and form sweat glands; sebaceous glands which are developed at the roots of hairs and supply a natural oil for the hair and skin are formed in a similar manner. The milk glands we have also seen arise along a ridge on the skin; they appear to have been evolved out of sweat glands. On the tips of the digits the epithelial cells of the skin are modified to form nails. The inner ear, which gives rise to a most intricate arrangement of parts for the transformation of sound waves into nerve impulses arises as a minute pocket of skin which sinks into the head until its mouth on the surface is closed. In some fishes the opening persists, the fish retaining in adult life an arrangement which is seen only in the embryo of higher vertebrate animals. The olfactory membrane also arises as a pair of skin pockets, which become enclosed by the parts which form the nose. Some of the epithelial cells of the olfactory membrane are so constituted as to be affected by odoriferous substances floating in the air. In the tongue certain cells are sensitized for taste; in the skin others are modified for touch. The lens of the eye, which focuses images on the retina, also arises as an epithelial ingrowth from the skin. It is even liable to the horny or corneous change which occurs in skin epithelium; when the lens becomes old, it often becomes corneous and opaque, giving rise to the condition of cataract. Thus it will be seen that the skin gives origin to a most complex series of structures, but we must suppose, from the facts of development just narrated, that man is the descendant of a stock which had a skin, simple in structure but complex in function, which served as a nerve system, gland system, as well as a body covering.

The anthropoid apes which in all structural features come nearest to man, have their bodies covered with hair, all except the soles of the feet and palms of the hand. We notice, however, that on the cheeks and forehead the hairs are short and not so apparent. How is it, then, that man is almost hairless and is thus so different to the anthropoids? We infer that man comes of a stock which was as hairy as the anthropoids. Hair roots are developed all over his body, except on the palms and soles. At the seventh and eighth months of fœtal life the body is clad with a fine downy covering—the lanugo. In the adult, especially in some individuals, the body becomes covered with rough hair. In some races, such as the Ainus of Japan, the hairy covering of the body is very apparent. In other races, such as the African negro, the skin is almost hairless. Occasionally we see human freaks in which the face and head, or even the whole body, becomes as thickly covered with hair as a terrier. Indeed, when we examine carefully the arrangement or "lie" of the hair on the upper extremities of man we see that in the upper arm it is directed downwards to the elbow while on the extensor surface of the forearm it slopes up to the elbow. In the upper extremity of the anthropoid apes the hair is also arranged in this manner. We cannot explain all these facts unless we suppose that modern man has come of a hairy stock with the hair arranged exactly as we see it in anthropoids. We do not as yet know how the hairless condition came about, but there are several lines of suggestive enquiry. Professor Elliot Smith has observed that there is a correlation between the evolution of the human brain and the disappearance of a hairy covering. The brain is linked up by sensory nerves with every papilla of the skin: the more nude and thin the skin the greater its sensitiveness and the greater the number of messages sent to the brain. It is, therefore, possible that the nude condition of our skin and the size of our brain are connected in some way. We have still to explain why and how the hair has disappeared. We have already seen that many points in the structure of man have been evolved by a retention of a fœtal condition. Now fœtal anthropoids are hairless until the third month before birth; if the fœtal condition then were to be retained or prolonged a hairless condition would result. The growth of the hair, too, is regulated by a mechanism which we do not know fully, but the secretion of the thyroid has a distinct influence on the nourishment of the skin and the growth of the hair. The deposition and absorption of fat is also influenced by thyroid secretion. The healthy human baby differs from that of the anthropoid in being plump, owing to the thick layer of fat which lies beneath the skin; it is also hairless. The two conditions are probably correlated, and the mechanism which brings the change about is probably a function of the thyroid. We have every reason to suppose that civilization—or rather an ample command of food all the year round—was acquired by man at a much earlier period in the history of the earth than we have hitherto thought. The human fœtus would be much more richly nourished when such conditions came into existence. The glands of internal secretion, such as the thyroid, would probably be affected. It is possible then that in man's hairless condition we see one of the first effects of civilization on the human race.

There is also another factor at work. In our likes and dislikes we do take the condition of hair into account, and in this way, as Darwin pointed out, individuals with hairless bodies, but with rich heads of hair, may have had the preference in sexual choice. We have already alluded to the fact that the sexual glands have a marked influence on the growth of hair which takes place at puberty.

The evolution of hair and of nails hardly comes within the compass of a book dealing only with the human body. The hairy covering of the body became evolved when the mammalian stock was emerging from a very primitive scale-covered ancestry. The hairs were at first produced under the scales, as may still be seen in some low forms of mammals, such as the armadillo and scaly ant-eater. In our bodies it may still be observed that the hair roots are arranged in definite groups of 3, 4 or 5, and it is supposed that such groups represent the hairs which appeared beneath one scale. The evolution of our nails also covers a long period of time. The claw-like nails of the primitive mammals first assumed a flattened shape in the thumb and great toe of the earliest primates. Whenever the digits became truly grasping organs the nails became flattened. In the monkeys of the old and new world the nails are still narrow and much curved from side to side, especially on the little finger and toe. In the great anthropoids they become more human in shape. Long and narrow nails in man, much curved from side to side, are really anthropoid in character. Nails then are not an especial human feature, they were evidently evolved long before the higher primates broke up into the present families.

The little toe especially, and also the corresponding finger, often show signs of retrogression. Not only are their segments or phalanges small, but the one on which the nail is set may fail to be separated from the middle phalanx. The muscles of the fifth digit are often diminished in size and even one or more of them may be reduced to a mere fibrous cord. The nail of the fifth digit often reverts to the claw-like form seen in the very lowest primates.

To appreciate certain features of the organ of taste, it is necessary to mention the arrangement of parts within the mouth and throat. We are accustomed to think of the tongue as a flat movable structure in the floor of the mouth. When, however, special means are taken to study the tongue in the living it is seen to be made up of two surfaces or parts, one situated in the floor of the mouth, and a posterior or deep part which looks backwards into the throat or pharynx. The part of the tongue within the mouth is covered with rough papillæ, and is used to move the food during mastication. As long as the food rests on this part of the tongue we still retain control over it; when, however, it passes backwards into the throat and touches the pharyngeal part of the tongue, it passes beyond our control and we must perforce swallow it. The front or mouth part of the tongue we may call the **voluntary area**; the posterior, deep or pharyngeal part the involuntary. Now at the line where these two areas of the tongue meet there is set a row of special papillæ. On these papillæ certain groups of cells (taste buds) are placed, and are linked up with the ninth cranial or gustatory nerve. When food comes in contact with these papillæ we experience the full sensation of taste. Before it can really come in complete contact with the papillæ the food has to cross the border between the voluntary and involuntary parts of the tongue where the taste papillæ are set. You see how cunningly nature can set a trap; she neither permits you to waste food nor to neglect the needs of the body; you have to swallow food and thus supply the needs of the body before the taste can be really enjoyed. In this respect we are in the same position as other mammals.

The manner in which the olfactory sense organ is developed has been already alluded to. Mention was also made on a former page (26) of the fact that the olfactory nerves were the only ones connected with the cerebral hemispheres, and that there is every reason for supposing that those great masses of nerve tissue which constitute the main mass of the human brain originally arose in connexion with the sense of smell. In mammals generally every one has observed that the nose is the dominant sense organ. It is plain that a dog's highest mental joys are smell memories. In the higher primates, especially in the civilized races of mankind, the sense of smell has fallen into a minor place among our special senses. We have no words to express our sensations of smell, and yet many of our most realistic memories of childhood are often associated with some impression which reached us first through the nose. The olfactory sense cells are situated only in the roof and upper part of the nasal cavities; we must sniff in order that the air inspired may come in contact with the sensory membrane.

In the human nose there still remains a trace of a peculiar outpost of the organ of smell. In herbivorous animals, like the sheep or ox, it is manifestly advantageous that the odour of each mouthful of grass should pass into the nose so as to give warning when a noxious plant has entered. Two openings on the roof of the mouth—the naso-palatine—are situated on the palate, just behind the upper gum. Above the openings, on each side of the septum of the nose, is placed a scroll of cartilage containing a detached part of the olfactory mucous membrane—a minute or secondary nose to sample the odours which escape into the nose from each mouthful of food. This little nose is named the organ of Jacobson, after the anatomist who discovered it. These openings on the roof of man's mouth are now closed, but they are clearly represented by vestiges, and so are the scrolls of cartilage and the detached piece of olfactory membrane. In the anthropoids the organ is also vestigial. How are we to explain these things ?

It would take us too far afield to describe the structure and mechanism of the organ of hearing. The manner in which the inner ear arises as a sac has been mentioned, but nothing was then said of the very important fact that in its beginning the inner ear was double in function. It not only served as an organ of hearing, but also as one of balancing. This double function it has retained in all vertebrates and a very beautiful mechanism —consisting of three semi-circular canals—is attached to the inner ear, which informs the brain of the movements and position of the head and body. When these canals are destroyed by disease we lose the power of balancing our bodies when we move.

At the end of the ear passage is set a membranous drum which vibrates with the waves of sound. The waves are conveyed to the inner ear by three small bones—the hammer, the anvil and the stirrup. The history of these bones is strange. The hammer was at an early stage of the evolution of mammals a part of the lower jaw; the anvil was the bone on the base of the skull with which it articulated. When mastication and molar teeth were evolved in the ancestry of mammals a new joint was formed in the lower jaw, and these two bones—the hammer and anvil—were taken into the service of the ear.

All these things sound too much like a romance. Yet what will the reader think when he comes to consider the human eye? Not that the human eye is peculiar; it is made of the same parts as that of the fish; it is the human brain which makes the human eye a source of joy and knowledge. We may marvel over the evolutions of the sense of sight and explain it as best we may; as regards the facts of its development in the embryo they are comparatively simple. Three different elements come into conjunction to form it. First there is the dipping down beneath the skin of a bud of epidermis to form the lens. When the bud of epithelium sinks inwards to form the lens the skin closes over the point of subsidence and becomes transparent, thus forming the cornea of the eye. The second element to form the eye grows out from the nerve tube or brain of the embryo. The outgrowth forms a cup round the lens bud; the cup itself becomes the retina and the stalk of the cup is transformed into the optic nerve. The third element is derived from the surrounding tissue of the head—the mesoblast. The cells of the mesoblast swarm within the cup and round the lens and form the transparent jelly within the eyeball. The outer coats of the eye, which enclose and protect the retina, also arise from the mesoblast.

It may seem to the reader that the short account which has been given of the development of the eye only makes its evolution more marvellous and mysterious. It must be remembered, however, that we are witnessing the result of a process which has been at work for millions of years. Indeed, since ever life appeared on the globe, and that is longer ago than the human mind can conceive, the processes have been at work which have ended in the compounding of an eye. It is an instrument which can focus the outer world and is attached to a brain which can partly understand that image. Yet with all its complexity the eye is but a triple compound of skin, brain and intervening tissue. One cannot expect the anatomist to unravel in a few years that which has taken the lifetime of a world to evolve.

We need not stop here to note the fact that the human eyes are set in the face so as to take in a common field of vision. That is not a peculiar human trait; binocular vision is common to the higher primates. Nor need we dilate on the remnant of a third eyelid or nicitating membrane which can be seen as a thin fold between the eyeball and the red caruncula at the inner angle of the eye. Evidently in the human ancestry a functional third eyelid had been present, such as can be seen in the eye of the cat. But allusion must be made to a very remarkable vestige of another eye now completely buried beneath the great mass of our brain. Mention has been made of a bridge of tissue—the corpus callosum—which unites the two cerebral hemispheres. Underneath its posterior end is a small body no larger than a barley or wheat grain, known as the pineal gland. Connected with this vestigial body are remnants of optic nerves and optic ganglia. One has to go down the animal scale to the most primitive form of lizard—Sphenodon—to see this body assume the shape of an eye. It is median, single, and looks out from the crown of the head, and even in the lizard is a remnant of a visual sense we have not discovered so far in its original condition. Yet there sometimes occurs in the roof of the human skull a foramen or opening exactly in the position which the pineal eye occupies in lizards. The place is always marked by two small openings for veins, and the venous blood channel, which sweeps backwards in the roof of the skull, often widens at the spot, and sometimes actually divides, leaving room as it were, for the appearance of a pineal eye —which, however, never comes to the surface.

Quite recently Professor Dendy has described the remnant of a curious organ in the brain of man which may have been connected with some peculiar form of sense organ. For a long time it has been known that certain large fibres occur in the central canal of the spinal cord of fishes. Their function is unknown. They begin in a patch of epithelium situated in the roof of the canal of the stem of the brain. Professor Dendy found that traces of these occurred even in mammals. He found the epithelial organ from which these peculiar fibres arise in the canal of the brain stem of primates. Ultimately he discovered traces of this epithelial organ in the brain of the chimpanzee and of man. We have here a fine example of the persistence of an organ which, in the higher vertebrates, is apparently quite vestigial in nature.

CHAPTER XIV

THE MECHANISM OF THE BODY

It is refreshing in these Darwinian days to open a book on anatomy which became popular in England rather more than a century ago. The book was written by Archdeacon Paley, and entitled "Natural Theology," the mechanism of the human body being one of the chief subjects of discourse. The Archdeacon had studied anatomy in London to excellent purpose under William Hunter—John Hunter's eldest brother—one of the best anatomists at the latter half of the eighteenth century. The Archdeacon expressed in clear and simple language the views which the anatomists of his time held of the human body. To them, it was a machine of superlative construction, the final work of a power which had created all things. How far the anatomists of to-day have departed from the Archdeacon's point of view may be seen from the preceding chapters. We have in later days neglected the study of the mechanism of the human body. Modern anatomists look on it as an organ. For a long time it has been known that certain large fibres occur in the central canal of the spinal cord of fishes. Their function is unknown. They begin in a patch of epithelium situated in the roof of the canal of the stem of the brain. Professor Dendy found that traces of these occurred even in mammals. He found the epithelial organ from which these peculiar fibres arise in the canal of the brain stem of primates. Ultimately he discovered traces of this epithelial organ in the brain of the chimpanzee and of man. We have here a fine example of the persistence of an organ which, in the higher vertebrates, is apparently quite vestigial in nature.

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It is refreshing in these Darwinian days to open a book on anatomy which became popular in England rather more than a century ago. The book was written by Archdeacon Paley, and entitled "Natural Theology," the mechanism of the human body being one of the chief subjects of discourse. The Archdeacon had studied anatomy in London to excellent purpose under William Hunter—John Hunter's eldest brother—one of the best anatomists at the latter half of the eighteenth century. The Archdeacon expressed in clear and simple language the views which the anatomists of his time held of the human body. To them, it was a machine of superlative construction, the final work of a power which had created all things. How far the anatomists of to-day have departed from the Archdeacon's point of view may be seen from the preceding chapters. We have in later days neglected the study of the mechanism of the human body. Modern anatomists look on it as an anonymous missive which has come to them through the post of Time, stamped with certain marks from which they try to interpret —and with some success—something of the whence and how it has come. With the best of intentions the writer has been unable to break away from the detective's outlook; with each new chapter he hoped to leave evolution behind him and study the cunning mechanism of the human body without a mention of creation or evolution. How far that can be done the present chapter will show.

The manner in which the head is jointed to the body is an example of an effective and most delicate mechanism worked out under circumstances of peculiar difficulty. The head, like the telescope, is so jointed that the eyes can sweep the horizon from east to west by a turning movement, and scan the heavens from base to zenith by a nodding or extensory one. In the very centre of the movement is placed the most vital structure in the body—the lower end of the stem of the brain, which issues from the skull by the foramen magnum to pass into the canal of the backbone as the spinal cord. We can flex and extend the head, rotate it from side to side, and yet the "silver cord" is never in the slightest degree injured. When we examine the anatomy of the parts we see that the nodding movements occur between the skull and the first vertebra or atlas, and that the rotating movement takes place between the atlas and the second vertebra or axis. This elaborate mechanism, which can be employed at all times with the utmost surety and safety, has been accomplished by a simple modification of the first vertebra. Like all other vertebræ the atlas was originally made up of three parts —a body, which forms the solid front wall of the canal for the spinal cord, an arch which encloses the canal at the sides and at the back, and a third minor element—the front bar. The body of the atlas or first vertebra of the neck has been transferred from its proper position to become fixed as a pivot-like process on the upper surface of the second vertebra or axis. The arch of the atlas having no longer a body to make up its anterior deficiency unites with the third or minor element—the front bar. The atlas thus appears ring-shaped; the pivot-like process of the axis lies within the front part of the ring. When the head is rotated so that the face is turned from side to side, the atlas, which supports the head, moves round the pivot which has been shaped from its own body. When, however, the head is rotated thirty degrees to one side or to the other, the movement is suddenly checked by special ligaments. Were the ligaments or bands of fibrous tissue not present, then the rotation might be continued until the arch of the atlas was carried against the spinal cord; indeed, in the dead body when the ligaments and muscles are divided, it is possible to rotate the head until the cord is completely crushed by the rotating arch of the atlas. Yet the writer knows of no case where death has been caused by a forcible movement of the kind just described.

While the joint between the atlas and axis is a perfect example of a "pivot-joint" that between the atlas and the skull, where nodding movements occur, represents a modified form of another type of joint—the "ball and socket." The hip-joint, where the semispherical head of the thigh-bone fits within the cup formed on the pelvis by the "acetabulum," is the most perfect example of a ball and socket joint in the human body. In order to allow the stem of the brain to emerge at the foramen magnum, the central parts of both "ball" and "cup" have been cut away. If the ball were perfect it would be placed over the foramen magnum and the cup within the arch of the atlas. Only a minor part of the ball has been left on each side of the anterior end of the foramen magnum, and all that is left of the cup are two corresponding sockets placed on the upper surface of the atlas. The centre of the joint is the position of least movement, and is occupied by the commencement of the spinal cord. The movements are limited and checked by ligaments and muscles so that in the most extreme movements of the head the vital nerve centres are not endangered. One marvels at the simplicity of the elements out of which the most complex and delicate mechanisms are formed. By transferring the body of the first to the second vertebra and by a simple modification of the joint between the first vertebra and the skull a mechanism has been secured which gives mobility to the head and safety to the nerve cord.

The various orders of levers might be studied at the joint between the head and body. The head is a lever of the first order; the atlas is the fulcrum which supports the lever. When the head is bent backwards, the power is represented by the muscles of the nape of the neck; the weight lifted is the front part of the head. The various kinds of levers, however, are better exemplified in the limbs, as well perhaps at the elbow joint as anywhere. We shall consider the forearm as a lever. If a weight be placed on the upturned palm and the forearm bent on the upper arm or brachium we see a lever of the third order. The elbow joint is the fulcrum; the power, represented by the biceps and anterior brachial muscle, is applied to the lever between the fulcrum (elbow joint) and the weight (hand), but much nearer the fulcrum than the weight. Power is thus lost, but speed is gained. It is apparent that the shorter the forearm or lever then the greater will be the purchase. Now it is a remarkable fact that man differs from the anthropoid apes in having a comparatively short and therefore powerful forearm. It is shorter in European than in African races. The gibbon is noted for the length of its forearm. If we watch the anthropoids using their arms in progression on the trees we at once realize the significance of their long and of our short forearm. The anthropoid seizes the branch with its hand and then draws upwards the weight of the body by flexing the arm at the elbow joint. The moving lever is not the forearm; it is the brachium or upper arm. We are still dealing with a lever of the third order; the fulcrum is still placed at the elbow joint; the power is furnished by the biceps and anterior brachial muscle, but is applied to the brachium, which is the moving lever, at some distance from the fulcrum, thus increasing power obtained. The weight is represented not by an object placed in the hand but by the whole body of the animal which is attached to the arm or lever at the shoulder joint. In the climbing anthropoid the upper arm is short and forms a powerful movable lever; in working man, the forearm is the movable lever, and therefore, compared to the brachium, is short and powerful. We see that the short forearm of man and the long one of anthropoids are functional modifications.

Having thus illustrated the first order of levers at the head, the third order at the elbow, we can see an excellent example of the second order at the ankle joint. In this case the foot is the lever, and we shall consider the mechanism of the foot and leg in walking. A step forwards has been taken by the left and the heel of the right foot is being raised to propel the body forwards. The pad of the foot and balls of the toes represent the fulcrum of the right foot; the power is applied to the rising heel by the muscles of the calf of the leg. The weight of the body falls on the foot at the ankle joint between the fulcrum at the toes and the power at the heel, but much nearer the power than the fulcrum. The nearer the weight is to the power, or putting the matter more briefly—the shorter the heel, the smaller is the purchase and the greater the muscle power required. Hence the races with short feet, high insteps and steeply set heels, have large calves. The foot, however, is a peculiar kind of lever; it is arched with the weight falling on the keystone of the arch. If the foot is long and slender, and especially if the weight falls near the centre of the arch, the more likely is the arch to break down.

It is sometimes said that the collapse of the arch of the foot is due to a giving way of the ligaments which bind the bones of the arch together. Those who hold this view of "flatfoot" overlook a very important function of muscles and the true nature of ligaments. Our bones are really not bound and kept together at joints by passive fibrous ligaments. There is only one joint in the body where this is the case, and that is at the knee joint. As we take a step forward we bend the knee, the bones being then held in apposition by the active muscles which end round the knee; then as we bring the weight of the body upon the outstretched leg the knee is straightened out, the ligaments becoming tight and pressing the bones together, thus securing the joint as it supports the weight of the body. At the very end of the movement the lower end of the thigh-bone undergoes a peculiar rotation inward and backward which locks the joint and secures it more firmly. At all other joints muscles keep the bones in apposition except when the movements become forced or extreme; it is only in these extreme movements that the ligaments take a part in limiting the action and securing the joint. This is also the case with the ligaments of the arch of the foot. When we stand, the arch is maintained by the steady and continuous action of muscles. Some of these pass along the sole of the foot from heel to toes, and act like the tense string of a bow, but the chief supporting muscles are situated in the leg, and sustain the arch of the foot by means of long tendons. Every one knows how tiresome a thing it is to stand still; it fatigues infinitely more than walking, because in standing these muscles of the sole are continuously in action, whereas in walking they have alternate phases of action and rest.

Few people realize how complex is the act of standing and the great number of joints and muscles which are involved. Not a muscle of the foot is asleep then, all are in action binding the various parts of the foot together to form a solid supporting base for the upright body. A dead man, however stark death may have rendered the trunk, cannot be maintained upright without support. Even a statue needs to have its feet firmly bolted to the pedestal. In the living standing man all the muscles of the leg are in quivering action, balancing and stiffening the legs on the feet. All the time messages are passing from the muscles to the centres in the spinal cord, from which other messages are being issued to regulate and co-ordinate the muscles in their action. The knees may be locked by the mechanism just mentioned when we stand at "attention," but most of us prefer to stand with the knees slightly bent, with the knee-caps loose, and the muscles behind the knees in action, keeping the joint stiff. Every schoolboy knows how the standing posture may be upset by catching the knee-cap muscles off their guard by a blow delivered behind the joint. At the hip joint there is also a mechanism which saves muscular effort. In the front of the joint there is an extremely strong ligament (ilio-femoral); when we stand at attention we over-extend the body at the hip-joint, and this strong ligament in front of the joint becomes tense, supports the body, and thus saves the muscles. The spinal column is not stable by itself. It rests on the sacrum of the pelvis, the pelvic basin in turn resting on the thighs at the hip-joints. The vertebræ of the backbone—five in the loins, twelve in the dorsal region, seven in the neck, making twenty-four in all—are balanced one upon the other and maintained erect by the exceeding complex musculature of the back. The twelve pairs of ribs, besides serving the purposes of respiration, also act as levers for the backbone. The great sheets of muscles in the wall of the abdomen and thorax, which come into action and support the viscera when we stand up, at the same time act on the ribs and through them balance the spine and trunk. Then the head is balanced on the spine by the muscles of the neck; every one notices how the balance of the head is lost as the seated sleeper nods. The shoulders, too, have to be kept up by the muscles; the great muscular sheet (trapezius) which descends from the head and neck to the prominence of each shoulder, is in action every minute we are in the upright posture. In time an aching feeling of fatigue may settle on the shoulder when the contracting power of the muscles is exhausted. Thus standing is an exceedingly complex act, which involves the majority of the muscles of the body. All the muscles involved are regulated and co-ordinated unconsciously by a silently working but elaborate reflex nervous system.

One of the most marvellous adaptations of our bodies is the manner in which bones are built to meet the strain and stress to which the skeleton is exposed during life. The material of the bones is so arranged that the greatest strength is obtained at a minimum expenditure of building material. The skeleton is not a dead inert framework in the living body; although it is chiefly composed of calcium salts yet we have good reason to suppose that every particle of a bone is alive. When from illness or idleness the bones are not exposed to strain or stress, they atrophy; their tissue is partly removed and the living cells or osteoblasts which permeate every part of a bone are lessened in their building activity; absorption of old bone takes place at a greater rate than deposition of new bone. In men who are living active lives and taking vigorous exercise and have not passed the prime of life the opposite is true; deposition or growth exceeds absorption in rate. The cells of the bone are sensitive to the forces which are brought to bear on them. This is very well seen when the bones of the arch of the foot are laid open by a vertical section which passes from heel to toes. In the heel bone which forms the posterior pillar of the supporting arch, the building cells or osteoblasts have laid the bone down in long needles running in the direction of the transmitted weight—from the base of the heel upwards and forwards to the ankle joint. These supporting needles are bound together by fine transverse plates, the whole system of the heel bone being enclosed within a thin shell. In the front pillar of the arch of the foot, the needles of bone are arranged so that their direction is from the bones of the toes backwards and upwards to the ankle. The systems of the front and back pillars of the foot meet and cross in the keystone of the arch—the astragalus or ankle bone.

In the upper extremity of the thigh-bone there is a more complex system. The neck of the femur serves as a bracket to fix the head of the thigh-bone to its shaft. When we stand on one leg the whole weight of the body is transmitted by the neck of the thigh-bone. When the neck is laid open it is seen that the osteoblasts have laid the bone down, and are maintaining it in two main systems. One of these—the supporting system—passes down from the head of the thigh-bone to join the system of the shaft; the other system forms a tie series passing outwards transversely from the head to the upper end of the shaft. The bone systems thus described in the neck of the thigh-bone correspond to the oblique and horizontal rods seen in the brackets of old-fashioned street lamps. If, however, a fracture of the femur occurs and the lines of force or of support are altered then the osteoblast will meet the new conditions by rearranging the system of bone trabeculæ or needles.

It is only in short bones or at the extremities of long bones that the osteoblasts lay their material down in specially arranged needles, plates or spongy patterns. In the shafts of long bones the material forms a hollow cylinder with dense walls. Engineers are well aware that the strongest support is obtained with the least expenditure of material by using hollow cylindrical pillars.

There is no end to the wonderful mechanisms of the human body; many chapters would be required to deal with them exhaustively. Some of the most beautiful examples are seen in connexion with the heart and lungs, but we will put these aside and merely mention one which excited the admiration of Archdeacon Paley. "It has been said," he writes, "that whenever nature attempts to work two or more purposes by one instrument she does both or all imperfectly. Is this true of the tongue regarded as an instrument of speech, and taste and deglutition? So much otherwise that nine hundred and ninety-nine persons out of a thousand, by the instrumentality of their one organ, talk, taste and swallow very well. . . . There are brought together within the cavity of the mouth more distinct uses of parts executing more distinct offices than I think can be found lying so near to one another, or within the same compass in any other portion of the body." That is true, and during the century which has elapsed since his words were written we have become aware that the mechanism of mastication, of speech and of swallowing is more complicated than even Archdeacon Paley supposed. During mastication the mandible undergoes an extremely complex series of movements, which are regulated and controlled at each phase by a special system of muscles and nerves. The carpet of glands spread everywhere beneath the mucous membrane of the mouth, lips and tongue, is reflexly called into action by another nerve mechanism and throws out a lubricating secretion which moistens the lips, cheeks and gums. The three pairs of salivary glands situated in the cheek (parotid) and under the jaw (submaxillary), and under the tongue (sublingual) are stimulated by another system of nerves to pour their secretions into the mouth. At meal times neither speech nor respiration need be interrupted.

The mechanism of the throat or pharynx is also complex. A bolus of food, when it has been passed from the mouth to the pharynx in the first stage of swallowing, finds four passages open for its further progress. It may return to the mouth, it may pass into the naso-pharynx and nose: it may pass into the larynx or windpipe. These three entrances or passages to the pharynx are kept open except during the act of swallowing. There is a fourth passage or opening leading to the œsophagus which is always closed except when pushed open by a bolus of food or mouthful of fluid. Before the bolus of food which has just reached the pharynx can be seized by the muscular wall of that cavity and propelled onwards, it is necessary that the passages to the mouth, nose, and larynx be shut and the opening to the œsophagus relaxed or open. An elaborate system of muscles, under the control of an automatic nerve mechanism, accomplishes all these things with every mouthful we swallow. Swallowing seems such an easy and automatic act that we are quite unaware of the elaborate system of signals, side shunts and level-crossings which have to be manipulated to permit the busy traffic of the pharynx to pass unchecked. A bolus of food in the pharynx brings reflexly all of these into action, but there are occasions when their efficiency is disturbed by an urgent and unexpected message from the larynx or the nose. In other words, a morsel of food in the windpipe which has passed the sentry at the larynx at an absent minute calls other muscles into play and upsets the normal mechanism of swallowing. The movements carried out under the active guidance of the brain form only a fraction of the work which goes forward in the body. The elaborate movements of respiration, the mechanism of the heart; of the arteries, of the veins, the regulated contractions of the stomach and bowel, besides many movements of the body, are being conducted and regulated day and night by nerve centres and systems over which we have little or no control.

CHAPTER XV

DEGENERATION AND REGENERATION

Some years ago everybody was alarmed by the statement that our national physique was in process of decay. The question whether this was the case or not could have been decided with ease if exact measurements had been made of the generations which have lived in this land before us; but unfortunately facts relating to the ancient British are very few. Professor Karl Pearson with his pupils made a searching enquiry regarding the stature of prehistoric people, and came to the conclusion that "the average Englishman of to-day is certainly not behind his Anglo-Saxon ancestor." Indeed the evidence is almost positive that modern men and women are taller than their forerunners of a thousand years ago, but the difficulty of making a dogmatic statement is increased by the fact that in all times stature has varied with class. Galton found that the men of the commonalty of modern England had a stature of 1,700 mm. (5 ft. 7 in.); the middle class (Pearson) 1,728 (5 ft. 8 in.); the Oxford students (Schuster) 1,740 (5 ft. 8·6 in.).

How much the higher stature of the well-to-do classes is due to better breeding and how much to better feeding is not determined, but all the evidence points to inheritance as being the more important factor. Modern statistics leave no doubt about well-nourished boys and girls being taller and heavier than children of a corresponding age who are less well-nourished and cared for. We have no evidence, however, to show that under-feeding will undermine the growth-energy of a race; under-feeding stunts the individual but so far as we know leaves the stock unaffected. That, however, is no reason why any one should be underfed.

When we come to enquire into other features of our bodies we have less reason to form an optimistic opinion. There seems to be at least two parts or regions which are in a state of change. The first of these concerns the whole system of mastication—the teeth, the jaws, the face, and throat. The second includes the lower part of the bowel—the appendix—the cæcum and colon. These parts belong to the commencement and to the termination of the alimentary system. There is every reason to suppose that the degenerative changes in these two regions of the body are manifestations of a common cause; the races in which we find irregular teeth, contracted jaws, constricted throats are also the races who are subject to diseases of the appendix, cæcum and colon.

We may conceive two things to have happened (l) That these changes in the jaws, teeth and colon are simply the appearance of new racial features ; we are in the habit of saying such characters appear spontaneously because we have not yet discovered the cause of their origin. (ii) It may be that these changes which are taking place in the national physique are due to an alteration in the kind of food on which we modern peoples live. Our alimentary system was originally evolved to cope with the raw food of primitive man. Our digestive system may be unbalanced by the nature of our diet. Think for a minute how we stand in the matter of food as compared with the ancient Britons ! To-day the world empties her lap into England —wheat, flesh and fruit. Cooking and seasoning have altered the nature of a diet which in its concentrated nature and abundant supply forms a revolutionary change in the methods of life. The ancient Briton had only an uncertain and crude supply gathered from small field-patch, wood or river. Cooking is an art which comes with civilization ; primitive man may have roasted or broiled his meat ; he probably never boiled either his meal or vegetables.

The evil condition of modern teeth is notorious ; dental decay of course is preventable by strict cleanliness. In the skulls of Britons who lived in these islands a thousand years ago and upwards, it is usual to find the teeth sound, their crowns worn down by use, the palate well spread; the nasal cavities well formed, the cheek-bones well set. We have no reason to suppose that our remote ancestors used tooth brushes. It is true that bad teeth are also found in ancient European races; for instance, in the Tilbury man, one of the earliest of human remains yet discovered in England, many of the teeth have been lost during life; even in the European of the glacial period, dental disease may be seen. Such a condition was rare in prehistoric times; now it affects all. The teeth of prehistoric races of mankind are worn; the crowns are eroded by the act of chewing food which must have been tough and required vigorous mastication. In modern skulls of even quite old men it is usual to see such teeth as have remained sound in the jaws, quite unworn. We may draw one conclusion with the utmost certainty from the comparison of ancient and modern teeth—that the ancient and modern dietaries were totally different in nature. The old required vigorous mastication; the modern does not. We may also infer that the disturbance which is so widely affecting our teeth, jaws, nose and face is a consequence of that change in dietary. The writer must have examined at one time or another over 100 skulls of Neolithic people—people who lived in Britain 4,000 years ago or more, and has only seen one with a contracted palate and irregular teeth. Although contraction in the width of the face, narrowing of the palate, obstruction of the nose and throat are extremely common in modern children and adults, these conditions are never seen at birth. They become manifest as the permanent teeth erupt and come into use. The condition we are discussing is therefore not present at birth. While it cannot then be called hereditary it is possible that a susceptibility or tendency may descend from one generation to another in some families. All we can say at present is that a retrograde change does appear to be at work on the faces and jaws of highly civilized peoples and that the change is probably due to diet. Our diet has been altered but we can hardly expect nature to provide us at once with a mouth and teeth suitable to the new conditions of living. The contracted palate appears to be Nature's way of bringing our jaws into harmony with the kind of work we are giving them to do. Instead of waiting for Nature to act it would be more practical perhaps to alter our diet to suit the dental system we have inherited. Mention has already been made of the fact that the third molars in highly civilized people may be very late in erupting or may never cut the gum. The third molars are often deformed or much reduced in size.

Metchnikoff, one of the most intrepid students of life of our time, has boldly declared that the appendix, the cæcum and the whole of the great bowel—a massive and long tube with a highly-organized system of coats and tissues and vessels—are useless structures in the body of man. Nay, under certain conditions, the presence of the colic system may be a constant danger to life. Such a statement, coming from a biologist of the very first rank, is bound to carry authority and persuasion. If Metchnikoff's opinion is well founded then the colic system of man is a gigantic blunder in animal construction. We have always supposed that Nature made no mistakes.

The evidence in support of Professor Metchnikoff's theory is altogether unconvincing. We have not yet discovered the function of the various parts of the great bowel—the appendix, cæcum and colon. It has always been the custom to regard those organs whose functions or uses are unknown as useless, rudimentary or vestigial organs. As our knowledge of the body has increased the list of useless organs has decreased. Our knowledge of the human colic system is of the crudest. The function of the appendix we do not know, but in the human body at birth it is identical in form and structure to the appendix of the great anthropoids. It is when boyhood and girlhood are reached that it becomes liable to disease and to undergo reduction in size and contortion in shape.

We seem to be dealing with a change in structure of exactly similar nature to those degenerative changes which we have already noted in the teeth, jaws and throat. In their case it seemed most likely that their change in form is a result of diet and it seems very probable that the same statement will yet be proved to be true in the case of the appendix.

What little we know of the function of the colon favours the opinion—for our knowledge as yet is only a collection of opinions founded on a few facts—that the fault lies not in the colic system but in the nature of the work it is asked to perform in modern man. Its main work in our ancestors consisted in the digestion of the cellulose or husk elements of grains and of fruit and vegetables. Our modern dietary has called upon it to act upon a dietary totally different to that for which it was evolved. Should we then blame the colon and call it a useless structure?

Metchnikoff has helped us to understand the rich fauna of micro-organisms which flourishes within the colon. Under normal circumstances the bacteria appear to assist in colic digestion; nay, it is possible they are essential factors in colic digestion. We cannot conceive that the fauna which flourished in the colon of Neolithic man will thrive under the conditions which hold in modern man. Injurious forms of fermentations do occur within the great bowel of civilized races.

Absorption of fluids takes place from the colon. It is in the colon that the fæces assume their solid form. It is probably when the contents are injuriously changed by fermentation that substances are absorbed which poison the whole system. In cases where such pathological conditions prevail the surgeon will relieve a patient's condition by either removing the colon altogether or by performing an operation which will throw it out of action. If relief is thus obtained we must not infer that the colon is a useless organ ; all that can be said is that it is not indispensable to modern man living on a highly artificial diet. There are a very few parts of the body which the surgeon has not removed when their removal is necessitated by disease. Because a man can get along in life with only one arm or one eye we must not suppose that the second arm or the second eye were superfluous. There is another important fact known to all biologists; in the alimentary system of every vertebrate animal a part is specialized to serve the purpose of a colon. It is not likely that such an ancient and essential part of the animal body should suddenly become useless. The evidence, so far as it goes, leads one to think that the kind of food and the nature of cooking now used by highly civilized races are unsuitable for our alimentary systems. We can hardly expect evolutionary processes to keep pace with our pampered and often extravagant appetites. As rational beings we should try to adapt our diet to the colon rather than expect that structure to adapt itself to our diet. Still, whatever the cause and the cure may be there can be no doubt that certain parts of our alimentary systems are out of harmony with their modern surroundings.

As regards the other systems of the body, the brain and nervous system, the muscles and bones, the writer is not aware of any modern change which can be detected in them, with one exception. The long bones of the lower limbs appear to be altering in form. In the thigh-bones of the early British, as late as the date of the Anglo-Saxon invasion, there is a peculiar flattening of the upper end of the femur. The leg-bone or tibia of these is often flattened from side to side, giving it a sword-like shape. Thigh and leg-bones of this type are uncommon in our modern population. The meaning of the change in femur and tibia we do not understand. Some have attributed these ancient characters to the habit of squatting; others have supposed them to indicate a people who were accustomed to hill climbing.

Thus it will be seen that there is no symptom of bodily decay in modern man if we except —and they are important exceptions—those of the alimentary system. The so-called signs or stigmata of criminalism have already been briefly alluded to in connexion with the outer ear.

The specialization of modern life does compel men and women to spend their lives under conditions which are ill-suited for maintaining the body in a state of fitness and health. The growing body cannot develop normally unless the muscular system is regularly and naturally exercised. At no time has physical culture been more widely popular than at present. It has effected much that is good and perhaps a little that is really harmful. We see modern methods of physical culture replacing the exercises of the drill-sergeant of a past generation. The ideal human body, in the opinion of the old drill-sergeant, was that of a man at attention, with head thrown abnormally back, pouting, expanded chest, enclosed within a tightly-fitting tunic, back rigid, muscles tight and brawny, toes turned outwards. That was his ideal, and it was wonderful how he succeeded in turning raw recruits into these parade soldiers. The ideal of course was wrong; agility, health and endurance were sacrificed to parade effect. The ideal, too, which is the aim of so many modern "professors" of physical culture is equally wrong. They aim at producing a voluminous chest and a Herculean musculature. They cultivate in their pupils a muscle system which would fit them to earn their livelihood as navvies. Such an over-development, we shall see, is always bought at a price.

Let us first examine the question of chest development. The respiratory movements—their rate—their amplitude—are determined by the condition of the blood in the lung. The harder the muscles work the greater is the volume of impure blood which reaches the lungs and the greater must be the chest movement to supply the respiratory exchange. In children the best respiratory exercises are obtained by allowing them to run in play, to contest in games. The condition of the blood thus produced will stimulate the free respiratory movements and a natural development of the chest. No artificial breathing exercises will improve on Nature's mechanism. When men and women lead sedentary and quiet lives their lungs are partly shut down; the respiratory system works at less than half its capacity. It is important that at one period of the day at least the lungs should be tested to their full power, for if we do not use them occasionally at their full capacity, then our ability of responding to an effort will certainly be lost in time. The true test for our chest and lungs is: are they equal to meet the demand made on them by physical efforts?

If we examine men and children closely we shall see that no two individuals use exactly the same movements of the chest in breathing;

our respiratory movements vary as much as our handwriting. Both can be improved; but there is no absolute ideal; each must be improved or corrected according to its type.

In recent years the writer has had opportunities of examining the greatly expanded chests of men who were ardent pupils at schools of physical culture. In every case the respiratory movements differed in type from those in men of corresponding age who were in fit condition, but had not gone through a special training. When a breath is taken by a normal man it is usual to see the upper wall of the abdomen—the epigastric region—swell forwards under the pressure caused by the descent of the diaphragm, and the viscera under it. In those with specially expanded chests this movement is absent; the diaphragm in those pupils instead of depressing the viscera is held up by them and exerts its strength in lifting the whole chest upwards. The greatly expanded chests do not indicate respiratory capacity, for it is seen that the artificial expansion of the chest has been obtained by elevating the ribs to an inspiratory position. In normally formed chests the ribs are placed obliquely, sloping forwards and downwards. When a breath is taken the capacity of the chest is increased by raising the ribs to a position which is nearer the horizontal. In specially, but wrongly, trained men the ribs, even during expiration, are maintained in an inspiratory position, the respiratory capacity of the chest being thereby limited. When these expanded chests are lighted up by means of X-rays the heart is seen to be big and hypertrophied, the lungs are more voluminous than they should be in healthy young men. Such pupils are artificially overtrained; when the exuberance of youth is over they will fare worse in life than those who have kept themselves naturally fit. The lungs are really delicate and complex structures, and the fact cannot be over-emphasized that they can be injured by over-expansion quite as readily as by compression of the chest. So far as concerns the form of chest our ideal must not be the prominent expanded type so often portrayed on the posters of the professors of physical culture.

Unless the muscles of the back are kept in use in the young the spinal column is certain to develop irregular and injurious curvatures. We have already pointed out that in the erect posture, whether seated or standing, all the muscles of the spine are in action. Continuous action soon produces fatigue. The child, seated at the school desk, quickly discovers how the sense of fatigue may be relieved. The weight on the spine is relieved by inclining the head until it is supported by the arm flexed on the desk. Further ease is obtained by allowing the body to bend sideways and obliquely, for in this manner the side joints of the vertebræ come to rest on each other and thus the muscles are relieved. In a short time the bones and muscles accommodate themselves to the assumed posture; only special exercises and great care will prevent spinal deformities from becoming permanent. Modern teachers are well aware of the danger of keeping their pupils seated or standing for a long lesson; they rest their pupils by giving them exercises. The natural exercises are those of play—running, jumping, climbing—all forms of active games.

In every healthy individual there must be a correspondence between the size of the heart and development of muscles. Modern physiologists are keenly alive to the part which muscles play, not only in using the blood but also in forcing it back to the heart. Normal chest movements also assist the circulation. It is, therefore, evident that those movements of the body used as morning exercises—flexion and extension of the body, movements of the limbs—are really means by which we can exercise both our hearts and lungs. The greater the current of blood forced towards the chest the greater must be the activity of heart and lungs.

There is one aspect of muscular and breathing exercises which is often overlooked. Right exercises should also improve our control of muscles; no muscle acts by itself; it is always acting against an opponent.

When the index finger is bent not only are the bending muscles in action but so are the extending ones. From beginning to end of the act the mind automatically controls or balances the one set against the other. Teachers of singing, as the writer learned from the well-known treatise on singing by Mr. Shakespeare, are well aware of this. They strive to teach their pupils to balance and control their respiratory movements; from the point at which inspiration begins to the point at which the following expiration ends, both muscles of expiration and inspiration are in action, and at every phase of the act are under not a conscious but an automatic control. In learning to sing the control of the muscles is at first conscious; by practice it becomes unconscious.

It was the writer's intention to discuss what may be termed the ideal form of the human body; the subject, however, is too complex to be dismissed in a paragraph, and must be alluded to only. Artists of all ages have striven to shape their ideal of the human figure so that the head, the neck, the body and extremities bear a definite relationship to each other. The height of the head is accepted by most modern artists as a standard; French artists think that the height of the head, measured from the level of the crown of the head to the level of the chin, with the model's eyes directed forward in a horizontal plane, should equal one eighth or 12.5 per cent. of the stature. Anthropologists find that the head is about 13 per cent. of the average male stature, and 14 per cent. of the average female stature, while in a baby at birth in place of being one-eighth it is almost a fourth (23.5 per cent.) of the total height of the body. The ancient artists of Egypt and Greece constructed the ideal human frame so that the stature was $7\frac{1}{2}$ or $7\frac{2}{3}$ heads in length—thus conforming to the proportion which anthropologists have found to be true of modern man. It is quite certain that no artist or medical man has ever seen a human body which conforms in every detail to the absolute ideals which have at various times been postulated. The ideal is really a composite and imaginary figure and the ordinary man and woman need not be disappointed if in the shape and proportion of their bodies they fall far short of the classical ideals. After all the true test of the body is how it stands the wear of time and the work of life; the best of health may be sheltered within a rugged, ugly body. What one may well envy is the easy pose, the well-balanced action of the muscles which characterize such classical figures which are really beautiful.

CHAPTER XVI

THE GENEALOGY AND ANTIQUITY OF MAN

In all the foregoing chapters we have been examining and reviewing facts which bear more or less directly on the origin of man. In this final and brief chapter we propose to knit the various threads of evidence together and see how much we really know and what we merely guess concerning the genealogy and antiquity of man. The reader's first difficulty is—unless he is already familiar with works on geology—to obtain a true perspective of the recent periods of the earth's history. The names of geological epochs—Pleistocene (Quaternary), Pliocene, Miocene, Eocene, may mean little to him. We have to picture those periods from what we know of the present or recent period. The Recent period is regarded as stretching into the past until the glacial or Pleistocene period is reached. We have the most hazy ideas regarding the number of years which have passed since a more temperate climate settled over Europe; by some authorities the number is estimated at 15,000; by others at 150,000 years. We shall accept the larger figure as the nearer approximation to the truth and use it as a rough standard for the comparison of past geological periods. Now all through the Recent period we find remains of man modern in type and form; the evolution and origin of man is therefore to be sought for at an earlier date.

The period in the earth's history which preceded the Recent is known as the Pleistocene. It is characterized by periods of cold with temperate intervals. As regards its duration, it may be estimated at least ten times the length of the Recent period—probably even longer. In this period, too, we know of remains of man—of the type known as Neanderthal man. He is very different from modern man. Indeed, Professor Schwalbe and other competent judges regard Neanderthal man as a special species of man—*Homo primigenius*—while all modern men belong to the species *Homo sapiens!* Yet Neanderthal man had a very large, and, as we know from his flint implements, a capable brain. We can thus trace man into the Pleistocene period and through it almost to the beginning of that period, but not quite. The oldest Pleistocene man, whom we know only from a lower jaw found in strata near Heidelberg, is also of the Neanderthal type. We do not know the Heidelberg man's skull and brain, but have reason to suppose that both were highly developed. The Heidelberg man belongs to an early stage of the Pleistocene period, but there is evidence to show that man was evolved before this period dawned, for flint implements, of human workmanship, are found in strata formed long before the beginning of the Pleistocene period.

When we pass beyond the Pleistocene we enter the Pliocene period of the earth's history. This is a much longer epoch than the Pleistocene ; it is three or four times as long. Now, we know of no human remains which we can assign to this period with certainty, but it is very probable that the fossil remains found in Java, and ascribed to a human form to which the name of Pithecanthropus has been given, belong to the close of the Pliocene period. Many regard the stratum in which Pithecanthropus was found as having been laid down in the beginning of the Pleistocene period. His small brain and primitive skull indicate a much earlier period—probably Pliocene and not a very late part of that period. Thus, when we enter the Pliocene period we lose all certain trace of man. Some day remains will be found which will carry human history further into the past, but we must stop at this point now and take up the evidence from another point of view.

The Pliocene period we have seen was a long one—three or four times the length of the Pleistocene. The period which preceded the Pliocene—the Miocene—was longer still and the earlier period—the Eocene—still longer. Now we know the Eocene period was the one in which the mammalian forms of life came to the front amongst the types of vertebrate animals. The lowest forms of primates were represented then. At the beginning of the Miocene period the primates had made great progress. We have reason to believe that by the beginning of that period ancestral forms of the monkeys of the New World, of the Old World, and what is much more important to the student of human origin—the ancestral stock of the gibbons or small anthropoids had appeared. By the middle of the Miocene period we find fossil remains of Dryopithecus—the earliest form of the large anthropoids yet discovered. Now that is an important fact; by the middle of the Miocene period a large form of anthropoid had appeared for certain; it may have been evolved earlier. We can say with confidence from the evidence produced in former chapters of this book, that with the appearance of the great anthropoids the point in time is reached when we may reasonably expect the evolution of a human stock. The giant or great-bodied primates probably divided about this period into an arboreal and a terrestrial stock. The arboreal stock gave origin to the gorilla, the chimpanzee, the orang and the extinct ape, Paleopithecus, which we know to have lived in India during the Pliocene period; the terrestrial stock provided the ancestry of man.

Thus we can trace man back to the end of the Pliocene period, and there his traces are lost; we can trace the primate stock forward from the Eocene to the middle of the Miocene, when we see a form which indicates we have reached the point at which the human stock should branch off. From the middle of the Miocene to the end of the Pliocene is as yet a blank in the history of man, but who, on surveying the progress of the last twenty years, will say that this blank will not yet be made good?

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