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No. 1. THE ANATOMY OF THE ORANG OUTANG,

By A. PRIMROSE

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THE ANATOMY OF THE ORANG OUTANG

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THE ANATOMY OF THE ORANG OUTANG
(SIMIA SATYRUS).

AN ACCOUNT OF SOME OF ITS EXTERNAL CHARACTERISTICS: AND THE MYOLOGY OF THE EXTREMITIES.

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A brief note concerning the external features of the Orang Outang was read by me before the Canadian Institute on December 18th, 1897. Since that time I have had an opportunity of dissecting the animal, and of consulting the literature on the subject. I propose, in this paper, to give a detailed account of some of its external features, and then to deal at some length with the anatomy of the muscles of the extremities. The musculature in the anthropoid apes is of great interest when studied from the comparative standpoint, and in the Orang, which I have been fortunate in securing, some unusual conditions present themselves which make the enquiry of special interest.

The anatomy of the anthropoid apes has excited the interest of scientists for very many years. The old anatomist Tyson[1] described the Chimpanzee two centuries ago. Whilst his paper is entitled "The Orang Outang, or the Anatomy of a Pygmie," it would appear that the creature which he dissected was in reality a Chimpanzee. Many anatomists since the time of Tyson have been interested in the anatomy of the anthropoid apes, and the reason the subject possesses so much fascination for the scientific enquirer was well expressed by Owen[2] more than half a century ago, when he wrote: "In tracing the successive stages by which the lower animals approximate the structure of man, the interest increases as we advance, and becomes most exciting when we arrive at the highest term of the brute creation. At this point every deviation from the human structure indicates with precision its real

1 Edward Tyson, M.D., "Orang-Outang, sive Homo Sylvestris, or the Anatomy of a Pygmie compared with that of a Monkey, an Ape, and a Man." London, 1699.

2 Richard Owen, "On the Osteology of the Chimpanzee and Orang Utan." Transactions of the Zoological Society of London, Vol. I, 1835, p. 343.

peculiarities, and we then possess the true means of appreciating those modifications by which a material organism is especially adapted to become the seat and instrument of a rational and responsible soul."

Owen states that "the Orangs, or tailless apes of Africa and Asia, have long been recognized as the mammalia which make the closest approach to man ; and their organization has therefore been studied with more or less care and detail by many distinguished physiologists and comparative anatomists." This statement indicates the interest which had been manifested in the study of the anthropoid apes, more than half a century ago.

In addition to the Orang Outang, the group of anthropoid apes includes the Gorilla and the Chimpanzee, which inhabit chiefly the west coast of Africa, and the Gibbon, which is found in the Indian Archipelago and some parts of the adjoining mainland.

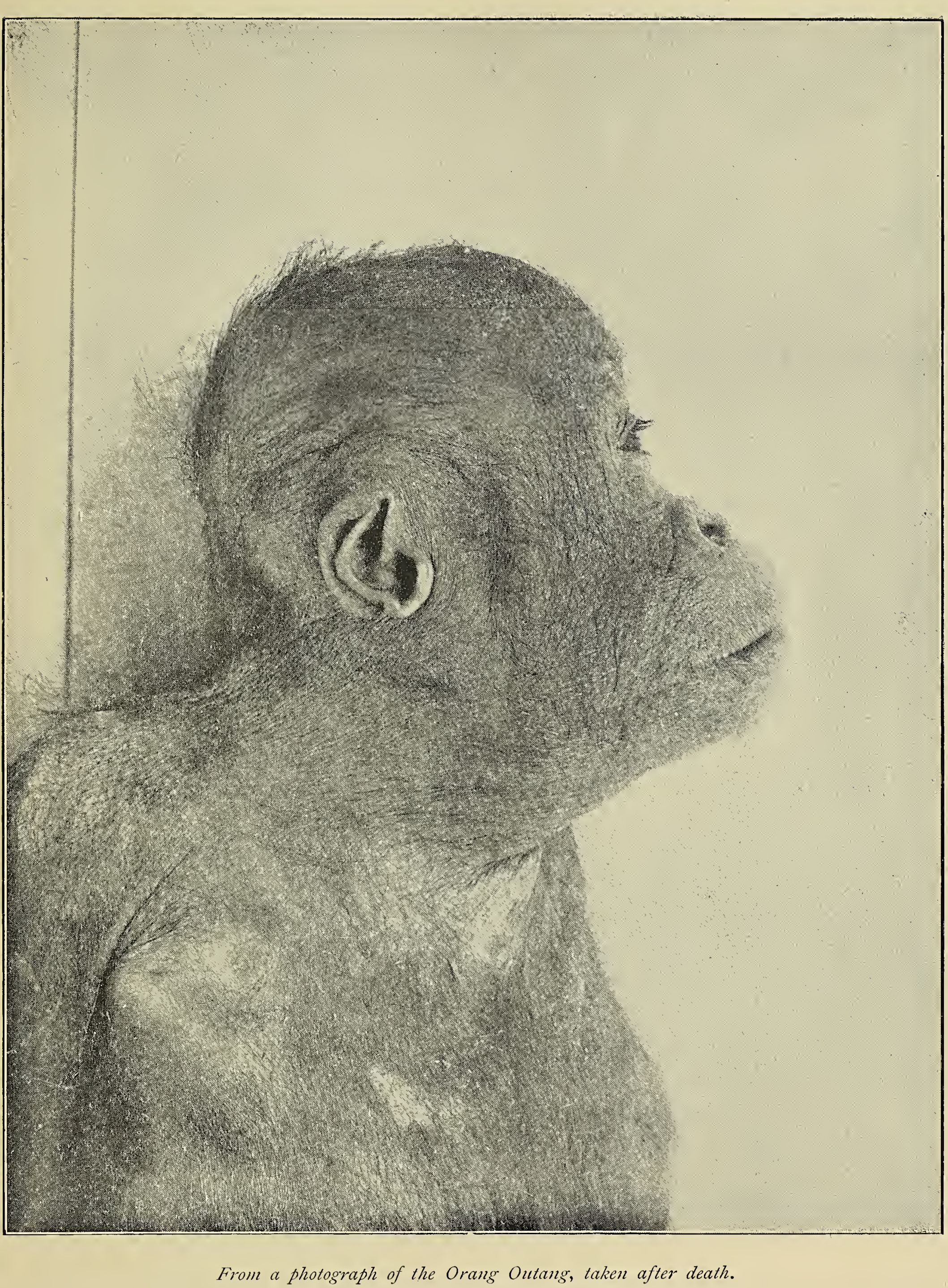
The Orang Outang is found in the islands of Borneo and Sumatra. It would appear that the creature never attains a great size. Huxley remarks that there is no evidence that they exceed 4 feet 4 inches in height. On the other hand, Rudolf Fick states that Clark Abel is reported to have found a species of Orang in Sumatra which reached the height of two metres ; this, however, Fick considers a gross exaggeration.

The specimen which I am about to describe was that of a young male animal (reproductions from photographs of the animal are published herewith). It measured 57 cm. in height. No history of its previous life and habits could be obtained. The shape of the cranium approaches, in many particulars, the human type. As has been pointed out by Hartmann[1] and others, the young apes approach more closely to the human type of skeleton than do the aged apes. Thus the great bony crests which are so characteristic of the skull of an aged male Gorilla are absent in young specimens. In all the smaller and middle-sized monkeys the general surface of the calvaria is oval and smooth, and remains so throughout life, whilst in the larger Baboons and Orangs there are well-marked supraorbital, sagittal, and occipital ridges.[2] These are said to attain their greatest development in the aged male Gorilla, where, as Flower asserts, they completely mask the original form of the cranium. In my specimen (a young animal) the surface of the cranium was perfectly smooth, and in this respect resembled the skull of a man, as there were no indications of crests.

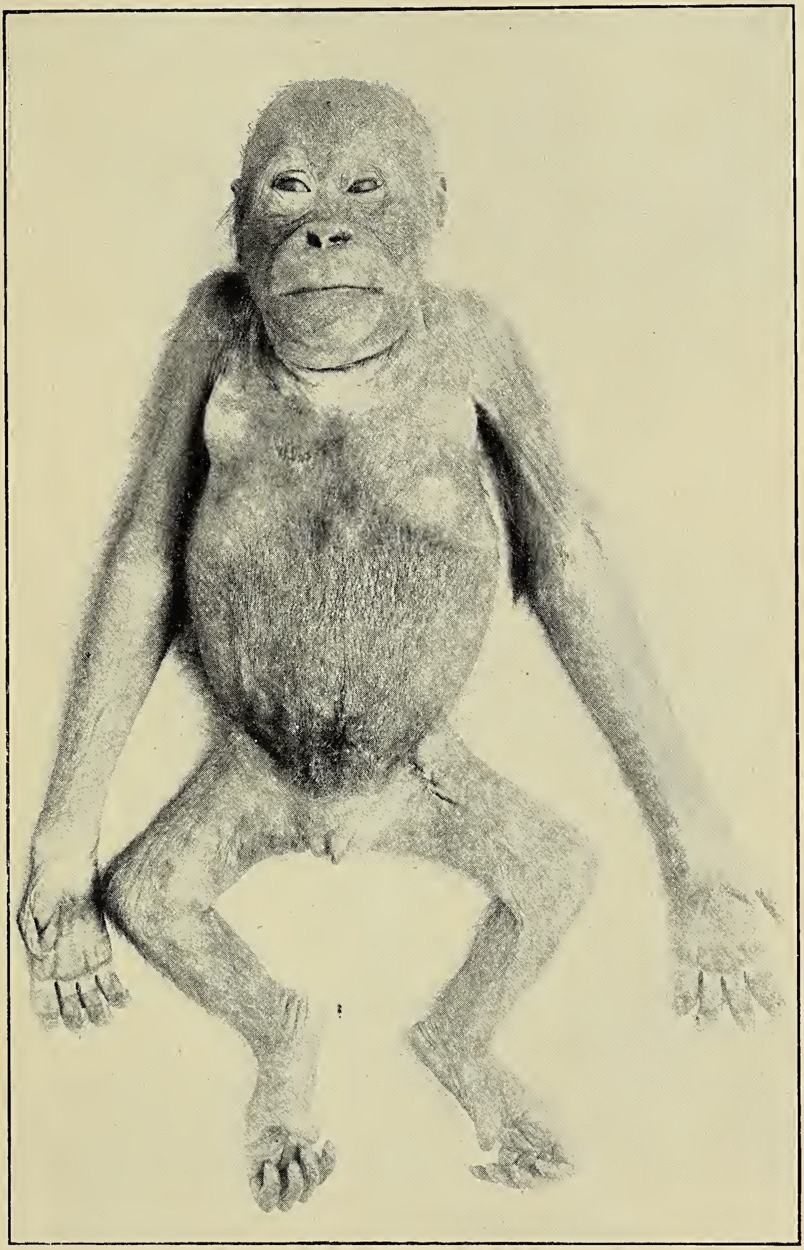
It would appear, however, that the bony crests develop in connection

1 Robert Hartmann, "Anthropoid Apes." New York, 1886, p. 107.

2 W. H. Flower, "An Introduction to the Osteology of the Mammalia." London, 1885, p. 162.



From a photograph of the Orang Outang, taken after death.



From a photograph of the Orang Outang, taken after death.

with the skull fairly early. Thus Delisle[1] observes that many crania exhibit well-developed sagittal crests, whilst as yet osseous union has failed to occur between the basioccipital and the basisphenoid. In man this union occurs about the twentieth year. Delisle describes the skull of an Orang, which exhibited this and other signs of youth, in which the crests were apparently in an early stage of development; the frontal crests, instead of uniting at the bregma to form the sagittal crest, passed backwards close to the superior border of the parietal bones, on each side of the sagittal suture, quite independently of each other, being separated by an interval of 2 cm. until they reached the occipital crest. This interparietal ridge may rise, according to Owen,[2] in the adult animal, to the height of one-third to two-thirds of an inch above the general surface. These crests give a massive appearance to the skull, but as Owen[3] long ago showed in his description of the skull of a Gorilla, the skull may be actually lighter than it is in man. This unexpected result is due to the greater size and extent of the air cells. Owen found that these extended in the Gorilla backwards from the tympanum, along the base of the occipital crests, as far as their junction with the parietal crest, and forwards also to the sphenoidal sinuses ; the frontal sinuses, and the antrum, were also developed to an unusual extent.

The dental formula in the Orang is similar to that of man. In my specimen none of the permanent teeth had as yet erupted, and the formula was as follows :—

$$\text{Milk teeth.....} \left\{ \; \text{I}\ \frac{2-2}{2-2}\ \text{C}\ \frac{1-1}{1-1}\ \text{M}\ \frac{2-2}{2-2} = 20 \right.$$

One finds that the dental formula in all the anthropoid apes is the same as that of man, and, in fact, such is the case in all the old world apes, with the exception of the Lemurs ; whilst, on the other hand, among the American apes there is considerable variation.

The lips are very wide and possess a wonderful degree of mobility. The mouth, in the living Orang, is said to be closed as a rule ; but, when the animal is taking food, the lips are used in a very curious

1 Delisle, "Sur l'ostéologie des Orang-Outans." Comptes Rendus de l'Académie des Sciences. Paris, 1894, Vol. CXIX, p. 241.

2 Loc. cit., p. 356.

3 R. Owen, "Osteological Contributions to the Natural History of the Chimpanzees, etc." Transactions of the Zoological Society of London, Vol. III, 1848, p. 412.

fashion. Thus, Fick[1] states that the lower lip may be protruded so as to form a kind of natural cup, so that if, for example, milk be given to the creature, he can fill this cup formed by the protruded lip, and then proceed to sip or lap the milk out of it. Darwin[2] refers to the protrusion of the lips in discussing the expression of the emotions in animals. He states that the lips of young Orangs and Chimpanzees may be protruded to an extraordinary degree; they thus act, not only when angered, sulky, or disappointed, but when alarmed at anything and likewise when pleased.

The eyelids are wrinkled, so that a series of grooves, parallel to the free margin, exists both in the upper and the lower lid. From the palpebral margin project well developed eyelashes. The eyes are never widely open in the Orang. They are placed very close together; Fick found, in the adult Orang that the pupils were only separated 5.7 cm., whilst in the emmetropic human eye they were separated 5.9 cm.

One of the most characteristic forms of expression in man is produced by the wrinkling of the forehead. Apparently the Orang does not possess this power to the slightest degree, although several observers have found the corrugator supercilii muscles present—muscles which produce the wrinkling of the forehead in man. It would appear, therefore, that the Orang has lost the power of using these muscles much in the same manner as man has lost the power of moving the ears. This lack of power of moving the auricle may be commonly noted in man, although the muscles in connection with it are developed. The facial muscles of expression in general in the ape are poorly developed in comparison with the same group in man. Bischoff is no doubt correct when he states that man differs from all animals, and from the highest apes very essentially, in the strong development and isolation of the facial muscles of expression. He concedes that the apes are excellent face-makers, but their emotions are expressed by distorting the whole face. The nose of the Orang is extremely short and depressed. There is no bridge and no point. The anterior nares look upwards and forwards. The shape of the ear in the Orang is remarkably like that in man. It possessed, in my specimen, the Darwinian pointed tip. This point, to which Darwin directed attention, consists of a small blunt process which projects inwards from the in-folded margin (the helix). In many monkeys the upper portion of the ear is slightly pointed, and the margin is not

1 Rudolf Fick, "Vergleichend anatomische Studien an einen erwachsenen Orang-Utang." Archiv für Anat. und Phys. Anat. Abth., 1895, p. 1.

2 Charles Darwin, "The Expression of the Emotions in Man and Animals." London, 1872, p. 140

3 Charles Darwin, "The Descent of Man." London, 1871, Vol. I, p. 22.

at all folded inwards. This condition, according to Darwin, occurs in monkeys which do not stand high in the order, as Baboons and some species of Macacus. When, however, the whole ear is pressed permanently backwards, and the margin is infolded, as in the higher apes, the point persists as the process mentioned. Darwin's point is found very frequently in the human ear, and whilst it is often absent in man, it is also not infrequently absent in the anthropoid apes.

In my specimen, the lobule of the ear was entirely absent. This peculiarity, too, is often found in man. The ears projected in a fairly well-marked fashion from the side of the head, although not more so than is the case in many human ears.

There was no prominence in the region of the chin in my Orang, and in this particular, it agrees with other anthropoid apes ; in fact, the forward projecting chin may be looked upon as a fairly distinctive human characteristic ; although Huxley states that in certain of the Gibbons (the Siamang) he found something approaching to a chin. He says, however, that this " is the only ape which has anything like a mental prominence." Again, Huxley remarks that whilst the chin in the European is either straight or projects beyond the level of the incisor teeth, in the lower races it retreats somewhat, although this recession appears greater than it really is, because of the prominence of the teeth.[2] In my Orang the recession of the lower jaw was such that a continuous curve was formed, which extended, without interruption, from the margin of the lower lip above to merge below in the outline of the neck.

The short thick neck of my Orang is a characteristic common to all anthropoids. The shortness of the neck is developed to a remarkable extent—to an extent seldom approached in man. It is due, not to shortness of the cervical spine, but, as Langer[3] has pointed out, to the shortness of the fibres of the levator scapulæ, and of the descending part of the trapezius muscles. The result is that the shoulders of the Orang are raised considerably above the level of the sternum, and the head seems to be sunken literally between the shoulders. This brings about an oblique position of the scapulæ, and a peculiarity of shape of these bones as compared with man.

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1 Huxley, "The Structure and Classification of the Mammalia." The Medical Times and Gazette, Vol. I and Vol. II, 1864, p. 618.

2 Ibid. Vol. I, p. 309.

3 C. Langer, "Die Musculatur der Extremitäten des Orang als Grundlage einer vergleichend-myologischen Untersuchung." Sitz. der math-natur. Classe der kais. Acad. der Wissenschaften, Vol. LXIX, Wien, 1879, p. 178-9.

In the cheek of man there exists what is called the buccal fat pad. This is a circumscribed mass of lobulated fat lying upon the buccinator muscle and the anterior margin of the masseter muscle, closely surrounding the duct of the parotid gland. It is particularly well developed in the cheek of the infant, and has been called the "sucking pad" on account of its supposed function in connection with the act of sucking. Symington[1] has demonstrated the relations of this pad of fat in the cheek of the child, and has figured the pads as they appear in coronal section through the cheek. Ranke[2] states that the existence of this pad was first described by Heister in 1732, who, however, mistook it for a gland, and called it the "glandula molaris;" and later anatomists followed this erroneous view. Ranke showed that it was surrounded by a connective tissue envelope, through which it was connected to the underlying buccinator muscle, and that a deep process of the mass passed backwards and upwards into the spheno-maxillary fossa under the ramus of the jaw and the lower part of the temporal muscle. It was found well developed in a four months' fœtus, and, while it persists throughout life, it is more noticeable as a well-defined structure in the infant. A peculiarity of this cheek pad is that, according to Ranke, it withstands the destructive processes which destroy the subcutaneous fat in many wasting diseases. Macalister[3] is apparently in error in making a statement to the contrary. These pads become unduly prominent when the neighbouring subcutaneous fat of the cheek wastes away. This sucking pad in my Orang was remarkably well developed. It formed an isolated mass completely separated from the subcutaneous fat, and presented all the features described as characteristic of it in the human infant.

In the Orang, as age advances, enormous masses of fat develop in the cheeks and in the neck. It is not certain whether or not these cheek pads are developed from the sucking pad already described—probably they are rather developed from the subcutaneous fat. At all events, in the old Orang, these later developments of fat attain great dimensions. They are fully described and figured by Fick.[4] According to his statement, they had not been previously described, but we find that Huxley[5] mentions them as occurring in an adult male Orang. The extreme

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1 Johnson Symington, "The Topographical Anatomy ot the Child." Edinburgh, 1887, p. 14.

2 H. Ranke, "Ein Saugpolster in der menschlichen Backe."
Virchow's Archiv für path. Anat. und Phys., Vol. XCVII, 1884, p. 527.

3 A. Macalister, "A Text book of Human Anatomy." London, 1889, p. 566.

4 Loc. cit., p. 2.

5 Loc. cit., Vol. I, p. 564.

ugliness of the old Orang is largely due to the existence of these cheek and neck pads. They form on each cheek semi-lunar appendages covered by the skin. In the dead Orang, Fick described them as triangular in shape. The free apex of the triangle was at the level of the malar bone, whilst the attached base of the triangle extended from the top of the frontal bone downwards to the lower margin of the lower jaw and face. Fick suggests that it occurs only in old age and in the male sex. These masses of fat are, to some degree, mobile; and Fick figures an Orang lying asleep, in which the cheek pad having fallen forwards, forms a cushion for the creature to rest its head upon. A similar development of fat occurs in the neck of the old Orang. Deniker and Boulart[1] describe similar voluminous pads of fat in the Orang—one 6 cm. thick, extended under the occiput and the nape of the neck; two others, in the form of semilunar crests 18 cm. long and 11 cm. wide existed on the side of the face and upon the jaws, and gave the animal a most singular appearance. This development of fat in the Orang appears to be connected with the age of the animal, and Fick suggests that it is comparable to the accumulation of fat which is apt to occur in man after a certain age is reached.

In my Orang there were no such free appendages of fat, but a mass of fat existed beneath the jaw, extending down over the hyoid bone and the larynx. Embedded in this were two thin walled sacs which were found to communicate with the air passages. They were in fact diverticula from the larynx, and were pyriform or egg shaped, attached above in the neighbourhood of the thyro-hyoid membrane; they diverged from one another, passing out under the sterno-hyoid muscles and after appearing in the neck on either side at the posterior border of this muscle, they came forwards towards the middle line. The sac upon the left side measured 5 cm. in its long axis and 2.3 cm. in its greatest width. The right sac measured 2.5 cm. long and 1.5 cm. wide. The sacs were very readily separated from the mass of fat in which they were embedded. It would appear that these sacs occupied an unusual position in my Orang in their relations to the muscles. In the descriptions which I have been able to consult they are figured as appearing in the middle line of the neck between the infra-hyoid muscles, whilst in my Orang they passed out behind these muscles and appeared at the posterior border of the muscles in the manner described. It is in the median position that Vrolik[2] describes and figures them in the Chimpanzee, as do also Deniker and

1 J. Deniker and R. Boulart, "Sur divers points de l'Anatomie de l'Orang-Outan." Comptes Rendus de l'Academie des Sciences. Vol. CXIX, 1894, p. 236.

2 W. Vrolik, "Recherches d'Anatomie comparée sur le Chimpansé," Amsterdam, 1841, p. 44 and plate 2.

Boulart[1] in the Orang. In former descriptions it has been assumed that these sacs are found only in the older animals; the great development of them in my young specimen disproves this statement. It would seem that they are seldom developed symmetrically, but one sac is always larger than the other. This disparity in size may be great; thus Deniker and Boulart found in one Orang the left sac measured 11 cm. long, whilst the right sac in the same animal was only 41 mm. The larger sac also often overlaps the smaller, and may completely conceal it lying in the middle line of the neck; this probably accounts for the circumstance that some anatomists have been led to describe the sac as a single azygos structure. Careful search in cases where the sac appeared single has led to the discovery that both sacs were present, one being of very diminutive proportions. Huxley[2] describes the great development of these sacs in a Gorilla in the following terms:—"The larynx in its general characters resembles that of man and the Chimpanzee; connected with it in the adult Gorilla is a system of great cavities, developments of the two laryngeal sacculi, each of which is equally dilated, and produced into large caecal sacculated pouches, extending all over the sides of the neck in the interspaces between the muscles, from the rami of the lower jaw to the axillae. As age advances the sacs of the two sides coalesce in the middle line over the trachea, and form an elongated bag, the upper end of which fits into the hollow of the body of the hyoid bone. The use of this immense and complex apparatus" Prof. Huxley adds "is not known."

The most extensive development of the laryngeal pouches is found in Duvernoy's description of the Gorilla.[3] In an adult male Gorilla a large median portion situated in the middle line of the neck was found, from which three pairs of lateral prolongations passed. Two superior ones, one on either side, passed upwards behind the angle of the lower jaw, passing back beneath the sterno-hyoid, the omo-hyoid and the sterno-mastoid muscles; these superior branches of the median sac had the most direct communication with the ventricles of the larynx into which they opened, immediately between the hyoid bone and the thyroid cartilage. These two superior branches also communicated each by a large aperture with the great median sac which descended anteriorly over the thorax and gave off a second and a third pair of lateral branches, with each of which its cavity freely communicated. The second pair (median)

1 Deniker and Boulart. "Les Sacs Laryngiens des Singes anthropoides," Journal de l'Anatomie et de la Physiologie, Paris, 1886, p. 51.

2 Loc. cit., Vol. I, p. 538.

3 M. Duvernoy, "Des caractères anatomiques des grands singes pseudo-anthropomorphes," Archives du Museum d'Histoire Naturelle, Paris, 1855-56, pp. 201, 202, 203.

descended to meet the clavicle, lying over its upper border as it passed outwards beneath the sterno-mastoid muscle to the upper part of the shoulder. The third (inferior) pair were by far the largest. They appeared to be derived as a bifurcation of the great median sac at its lower extremity. They extended downwards among the muscles of the anterior wall of the chest, each branch passing out laterally under the clavicular portion of the deltoid and downwards under the tendon of the great pectoral muscle and, whilst under this, insinuating itself between the two portions of the small pectoral muscle (superior and inferior) into which that muscle divided in the animal, passing even to the axilla, and lying there upon the lateral wall of the chest.

Huxley[1] in his description of the Orang states that the laryngeal saccules attain still more enormous dimensions in the adult than in the Gorilla; he describes them as constituting a great median bag covered by a strong layer of muscular fibres from the platysma and sending caecal prolongations backwards beneath the trapezius muscle as far as the occiput, beneath the scapula and into the axilla. The cavity communicated by two distinct canals with the ventricles of the larynx. Huxley tells us that among the Gibbons there is only one species—the Siamang—in which a laryngeal pouch at all similar to that found in the other anthropoids exists. One finds a description of laryngeal sacs in the Chimpanzee by Gratiolet and Alix[2] in which the left pouch extended down between the sterno-mastoid muscles a centimetre beyond the upper margin of the sternum. Cunningham determined the relations of the laryngeal sac in a Chimpanzee and in an Orang by means of frozen sections. In the Chimpanzee it extended downwards in front of the sternum to the lower border of the manubrium; it stretched in an upward direction until it reached the hollow posterior surface of the hyoid bone. In the Orang the laryngeal pouch, although it was prolonged down to the top of the sternum, was not continued on to the anterior aspect of that bone.

The occurrence of these sacs in the lower apes has been mentioned by Huxley, who found that among monkeys and baboons of the old world the sacs exist in many species ; they are not a development of the laryngeal ventricle in these animals, however, but grow out from the thyro-hyoid membrane, and have only a single aperture of communi-

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1 Loc. cit., Vol. I, p. 596.

2 Gratiolet and Alix, " Recherches sur l'Anatomie du Troglodytes Aubryi," Nouvelles archives du Museum d'Histoire Naturelle, Paris, Vol. II, 1866, p. 232.

3 D. J. Cunningham, "The Topographical Anatomy of the Chimpanzee, Orang-utan and Gibbon," Cunningham Memoirs, Royal Irish Academy, 1886, p. 138.

cation with the laryngeal cavity. In the apes of the new world some extraordinary variations occur in the development of these air sacs. In the spider monkey (Ateles) Huxley describes a single median sac which is developed at the back of the trachea, opening into the air passages between the upper ring and the cricoid cartilage. Then, again, in the howling monkey (Mycetes), according to the same authority, the hyoid and the laryngeal apparatus is exceedingly developed and modified. "The body of the hyoid bone is expanded into a great rounded drum with thin osseous walls, the larger cornua projecting backwards from it, though the lesser pair are quite obsolete. The thyroid cartilage is also exceedingly large, and the epiglottis undergoes an extraordinary development and changes in form. The cavity of the glottis presents several prolongations; one long and narrow tube in front communicates with the chamber in the body of the hyoid bone, the two lateral sacculi are prolonged upwards on each side, and are only separated from each other above the larynx by a thin membranous septum, and in some species there is, in addition, a small inferior pair of sacs."[1] The howling monkey, as its name implies, is capable of uttering loud and discordant sounds, and no doubt the complicated apparatus just described has something to do with the production of these sounds. It is difficult to understand how the mechanism acts, and I am not aware that anyone has succeeded in solving the problem.

I have thus given an account of the laryngeal sacs as they are found in the anthropoid apes and in apes lower in the scale. They are undoubtedly developed in connection with the laryngeal ventricles, structures which are present in the human larynx. These ventricles—the "ventricles of Morgagni"—lie in the lateral walls of the larynx, one on each side. The ventricle may be described as a recess which exists between the false cords above and the true cords below; it there forms a diverticulum from the lateral wall of the larynx, presenting an elliptical opening, the length of which is a little shorter than the true cords. The ventricle is about 5 mm. in depth, and, in man, from the anterior part a secondary diverticulum proceeds, the so-called "laryngeal pouch" which extends upwards for about 12 mm. towards the upper border of the thyroid cartilage; it is apparently this laryngeal pouch which assumes such enormous proportions in the Orang. According to Testut[2] this pouch is sometimes found considerably enlarged in man; whilst it usually terminates at the upper border of the thyroid cartilage, it may proceed upwards as high as the hyoid bone, or even sufficiently high to appear under the mucous membrane of the base of the tongue.

1 Loc. cit. Vol. II, p. 123.

2 L. Testut. "Traité d'Anatomie humaine," Troisième édition, Paris, 1895, Vol. III, p. 259.

The function served by the laryngeal sac, as I have said, is a problem not yet solved. Fick observed a slight bellowing of the sac in the Orang when the animal was howling, and he also noticed a slight blowing up of the sac in the second or expiratory act of yawning. In coughing, on the other hand, no effect was noticed upon the sac. Sandifort long ago suggested that the sac permitted the storing up of air which was brought into use in prolonging the loud roar of the animal, but, as Huxley pointed out, the position of the sac above and not below the vocal cords is inconsistent with this theory.

The great length of the arms in the Orang is a striking feature in comparing the animal with man. The lower extremities in man exceed the upper in length ; the reverse is true of the Orang. The measurements in my orang were as follows :

Upper extremity	46 cm.
Lower extremity	24 cm.

The measurements were taken in the case of the upper extremity from the tip of the shoulder to the end of the middle finger, and in the lower extremity from the perineum to the heel, thus following, for the sake of comparison, the method adopted by Fick. We find, therefore, that the upper extremity measured 80.7 per cent. of the total length of the body, whilst the lower extremity measured 42.1 per cent. of the height. The following table will give the percentages in a comprehensive manner, the figures indicating percentages of the total length of the body from the head to the heel :

	Upper Extremity.	Lower Extremity.
The present specimen of the Orang	80.7%	42.1%
Fick's Orang "Jumbo"	75.2%	38.3%
Fick's Orang "Anton"	73.6%	37.9%
Man	45 %	47.5%

Fick's measurements were taken from adult animals, whilst my Orang was quite young.

The remarkable elongation of the upper extremities in proportion to the body length is not characteristic of the Orang only, but of all the anthropoid apes. In the Gibbon this feature is even more marked than in the Orang or than in all other apes. It is interesting to note in this connection that the arms of negroes are proportionately longer than in the white races, this being, however, chiefly due to the increased length of the hand and forearm. Huxley tells us that the native Australians and other low races resemble the negro in this respect. One must note also that in this peculiarity anthropoid apes differ in a marked degree from the lower apes. Thus, in the lower apes, with very few exceptions, one finds that the lower extremities exceed in length the upper. In the Lemurs the hind limbs exceed the fore limbs to a very marked degree.

The hind limbs of the Orang are always bent ; it is impossible to straighten them completely. This is mainly due to the arrangement of the muscles at the hip and the knee. On the other hand, the fore limbs may be straightened out perfectly. I leave for consideration in another part of this paper the question as to whether the Orang is four handed or not, but in the meantime I shall speak of the "hand" of the fore limb, and the "foot" of the hind limb. The hand of the Orang is very much longer and narrower than the human hand. This is largely due to the great elongation of the metacarpal bones, but, in addition, the phalanges too are proportionately longer than they are in man. Fick states that the Orang grasps things by preference with the right hand, and that in all other manipulations they are decidedly right handed, as is common in most apes. The thumb is very short and rudimentary; it does not project as far as the head of the metacarpal bone of the index finger, and the ball of the thumb can hardly be said to exist. Much more remarkable, however, is the foot of the Orang. Like the hand, it is very long and narrow, but it has a well developed opposable hallux and is evidently modified as a grasping organ. The four outer toes are greatly elongated and remain separate, so that they resemble the fingers of a hand rather than the toes of a foot. It would appear that the Orang never stands erect without some support from the arms. Thus it may stand upright whilst it supports itself by grasping the limb of a tree overhead, or it may rest the fore limbs on the ground. Mayer[1] and others have observed that whilst resting on the fore limbs the Orang, like other quadrumana, does not place the palm of the hand on the ground when walking, but rests upon the outer margin and the back of the wrist and fingers. Whilst standing the foot is supinated and the toes bent, the foot resting upon its outer margin. This differs from the Gorilla, which is able to stand erect without the support of the arms, and is capable also of bringing the sole of the foot to the ground.

The lines upon the integument of the palm of the hand and of the sole of the foot in the Orang may be compared with the markings which exist upon the integument of the human sole and palm. If the palm of the hand in man be examined (see photograph) one may readily observe that the markings upon the palmar aspect of the fingers themselves are

1 Mayer. . . "Zur Anatomie des Orang-Utang und des Chimpanse." Archiv für Naturgeschichte, Berlin, 1856, p. 285.

obviously associated with the flexion or bending of the digits, the grooves existing opposite the joints at which the movement in question takes place. These grooves are converted into deep clefts when the fingers are fully bent. In the palm proper, similar markings on the skin are observed. Two very noticeable ones run almost parallel to one another from near the base of the index finger inwards towards the inner border of the palm. These grooves are about 1 cm. distant from each other. They do not run transversely across the palm, but their course is very oblique, the inner extremity of each line being much nearer the wrist than the outer extremity. These markings are associated with the flexion of the fingers upon the palm, and are converted into deep fissures when the fingers are folded in upon the palm. Certain markings run in a more longitudinal direction. These begin near the wrist. One is clearly associated with the movements of the thumb towards the palm ; it curves forwards from the mid-point of the wrist, around the base of the ball of the thumb, to terminate on the outer border of the palm, sometimes joining the nearer of the two oblique lines already described. This curved line is converted into a cleft when the thumb is opposed to the palm or to the other digits ; it is therefore clearly associated with the movement of opposition of the thumb to the palm or the other digits. Other longitudinal markings are associated with the adduction or abduction of the fingers. Occasionally the ball of the little finger is also marked off by a more or less distinct curved line.

Now, if we compare the foregoing with the markings which are observable in the photograph of the palm of the hand of our Orang (see reproduction of photograph) we find a corresponding series of markings. We notice, however, that the ball of the very rudimentary thumb in the Orang is not developed to anything like the proportions attained in man. The curved line at the base of the thenar eminence is present, but what is more marked is the cleft which indicates *adduction* of the thumb rather than *opposition.* Then one observes a very marked difference in the markings running across the palm. These are remarkable in being transverse rather than oblique in direction. We observe also certain less clearly marked longitudinal lines associated with adduction and abduction of the fingers. Let us now consider the significance of the difference in the markings in the human hand compared with those of the Orang. Professor Goodsir, of Edinburgh, long ago[1] well indicated a distinctive difference between the hand of man and that of the ape when he stated that the hand of man could grasp a sphere whilst the hand of the ape could grasp a cylinder.

1 "Goodsir's Anatomical Memoirs," Edited by Prof. Wm. Turner, Edinburgh, 1868, Vol. I, p. 239.

Clearly the oblique grooves in man indicate that the fingers are not bent in a perfectly straight direction into the palm, but are directed somewhat obliquely towards the thumb, hence the line associated with that movement of flexion is oblique, in other words it is at right angles to the line of movement—the fingers are opposed to the thumb. In the Orang, on the other hand, the fingers are flexed directly into the palm, and the animal is thus better able to grasp a cylindrical object, such as the branch of a tree, whilst it is not so well adapted to grasp a sphere, as the hand of man. The development of the ball of the thumb in man is due to the presence of a well-developed group of muscles which have to do with adduction and opposition of the thumb. These muscles are by no means so well developed in the hand of the Orang. It must be noted, however, that the groove of opposition is present in the Orang, and that the feeble thumb can be opposed. In the Orang, too, there is a marking off of the ball of the little finger; this is sometimes, but not always, present in the hand of man.

One would readily suppose that the lines in the palm of the hand were produced after birth when the muscles of the hand had brought about the various movements, but such is not the case. Professor Sir William Turner[1] makes an interesting observation regarding this when he says: "These grooves are present in the infant's hands at the time of birth; and I have seen them in an embryo, the spine and head of which were not more than 90 mm. (three and a-half inches) long. They appear in the palm months before the infant can put its hand to any use; though it is possible that the muscles of the thumb and fingers do, even in the embryo, exercise some degree of action, especially in the direction of flexion. These grooves are not, therefore, acquired after birth. It is a question how far the intra-uterine purposeless movements of the digits are sufficient to produce them; but even, should this be the case, it is clear that they are to be regarded as hereditary characters transmitted from one generation of human beings to another. They are correlated with the movements of the digits, which give the functional power and range of movement to the hand of man."

It may be remarked here that the grooves on the palm differ somewhat in the different anthropoid apes; thus Hepburn[2] shows that the lines across the palm in the Gorilla are decidedly oblique, and the hand

1 W. Turner, "Some Distinctive Characters of Human Structure," Report of the British Association for the Advancement of Science, 1897, p. 768.

2 David Hepburn, "The Integumentary Grooves on the Palm of the Hand and the Sole of the Foot of Man and the Anthropoid Apes," Journ. of Anat. and Phys., Vol. XXVII, 1892-93, p. 112.

of the Gorilla in this respect more closely resembles the hand of man than does the hand of the Orang.

The great length and narrowness of the hand has been referred to; it is quite obvious, however, that the fingers of the Orang are disproportionately short as compared with the greatly elongated palm. The cause of this is demonstrated by Langer[1] in his dissection of an interdigital membrane which spreads out over the upper fourth of the proximal phalanx of the four inner digits. This membrane is not present in man, and in the Orang, therefore, more of the proximal phalanx is sunken into the palm than is the case in man. The result is that the fingers of the Orang appear proportionately short. Another effect will be observed by reference to the photographs here reproduced, namely, that the integumentary grooves are further separated from the interdigital clefts in the Orang than they are in man.

Dr. Blake,[2] in his observations on the study of the hand for indications of disease, has noted the remarks made by Dr. Harry Campbell regarding the curious resemblance between the acquired bone and skin changes in the acromegalous subject, and the condition normal in the hand of the Gorilla. It would appear that many of the morbid changes in this disease bring about conditions of the character referred to, and Blake would view such as examples apparently of reversion to a primitive arboreal type. Whilst I am not prepared to seriously entertain this idea, there is no doubt of the fact, at all events, that in this disease the hand of man comes to present a curiously close resemblance, in appearance, to the hand of the Gorilla.

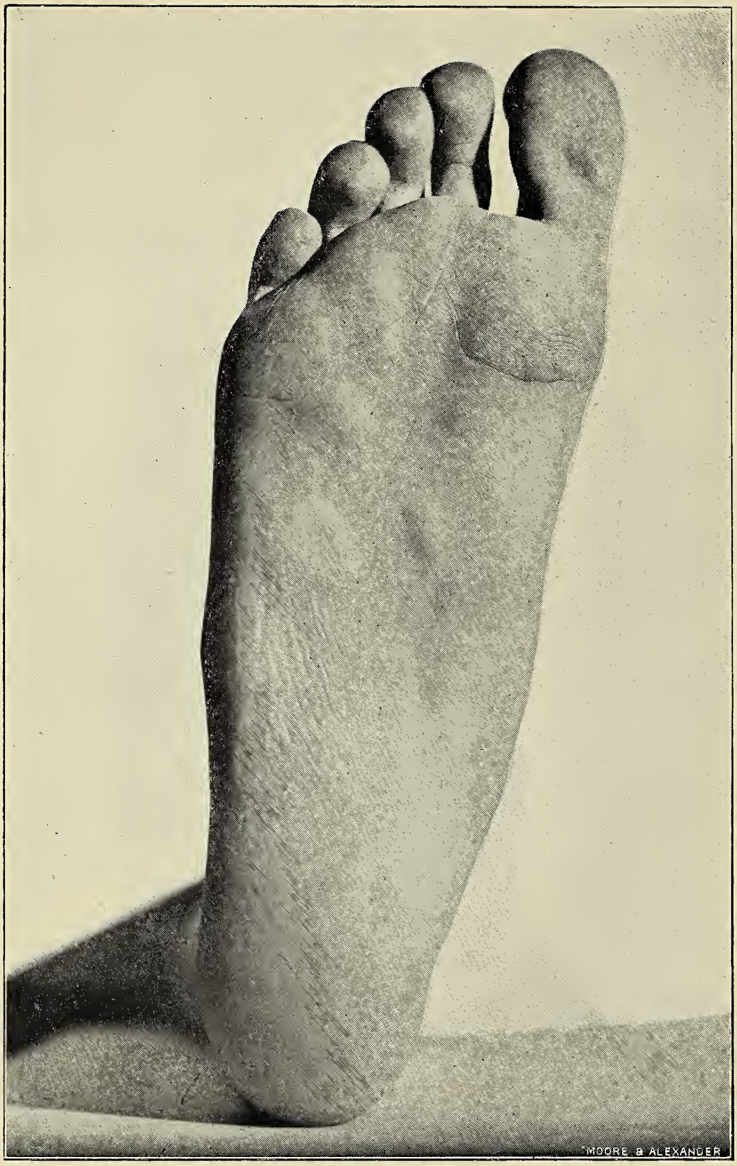
Turning now our attention to the markings in the sole of the foot, we find that in the human foot these are largely obliterated after the individual has walked about, and pressure has been brought to bear upon the sole, the skin becoming as a result thick and indurated. Some interesting observations on these integumentary markings, as they appear in the foot of the infant, have been made by Dr. Louis Robinson[3] in the "Nineteenth Century." He looks upon the markings on the infant's foot as giving some evidence of the evolution of the human foot from a structure which at one time was able to grasp an object after the manner of the human hand or the foot of an anthropoid ape. Robinson states that these lines are scarcely visible at fourteen months and are only present in a few cases after two years of age,

1 Loc. cit., pp. 182 and 185.

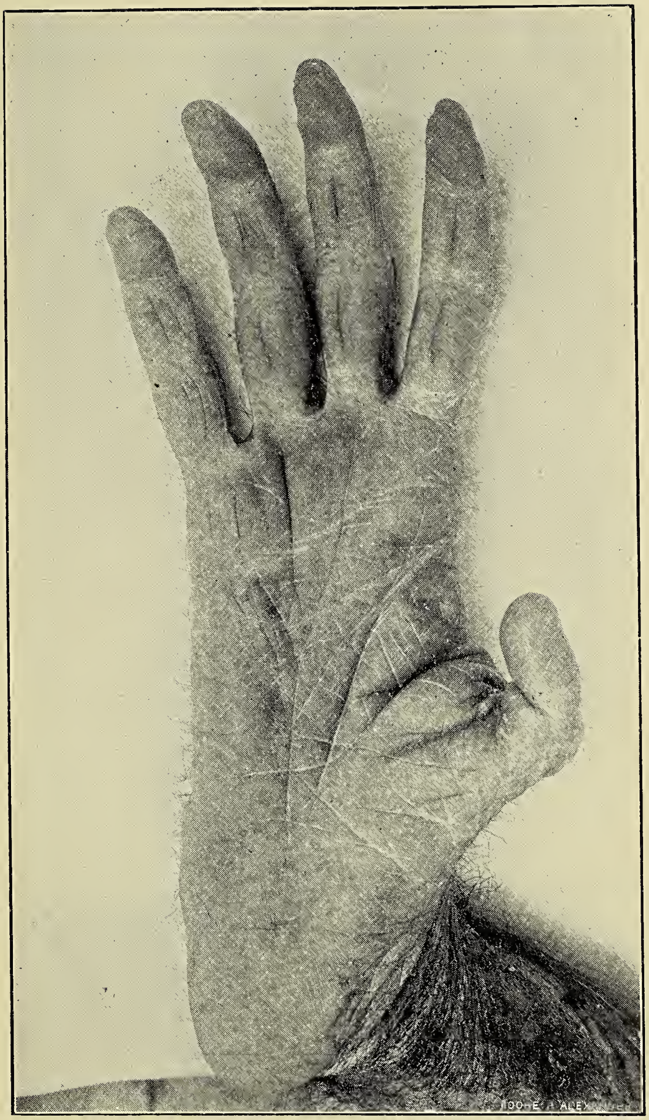
2 Edward Blake, M.D., "On the Study of the Hand for Indications of Local and General Disease," London, 1889, p. 36.

3 Louis Robinson, M.D., "The Meaning of a Baby's Footprint." The Nineteenth Century, Vol. XXXI, 1892, p. 795.

whilst in the adult they disappear. I have, however, photographed the sole of a child's foot aged nine years (see reproduction of photograph), and find well marked all the lines described and figured by Robinson in the foot of the infant. I shall proceed to describe these lines and to enquire into their significance. In the child of nine years one is able to distinguish the lines which correspond to the oblique lines across the palm. In comparing the foot with the hand, however, one must bear in mind that the great toe (unlike the thumb) is parallel in position to the other digits, and that its metatarsal bone is closely united to the other digits by an extension of the transverse metatarsal ligament, whilst in the hand there is no such connection of the metacarpal bone of the thumb to the index finger. The hallux is therefore not free to move about in the manner characteristic of the thumb. Moreover the hallux cannot be opposed to the sole or to the other digits, and if we examine the musculature in man we find there is no opponens hallucis. On examining the markings in the sole of the foot of the child (see photograph) we find a line strongly curved starting at the inner border of the foot at the base of the first digit, and passing outwards and forwards to terminate immediately external to the cleft between the first and second digits, its point of termination separated 1.5 cm. from that cleft. This line marks off what is commonly called the ball of the great toe, but observe that the so-called ball of the great toe does not correspond with the ball of the thumb, in that the soft structures forming the ball of the great toe are related to the plantar aspect of the proximal phalanx of that digit; whilst the ball of the thumb is formed by structures related to the palmar aspect of its metacarpal bone. This curved marking in the sole is therefore opposite the metatarso-phalangeal joint, and corresponds to the marking on the palmar aspect of the thumb opposite the metacarpo-phalangeal joint of that digit, and not to the curved marking at the base of the thenar eminence. This curved line in the sole therefore is produced by flexion of the hallux at the metatarso-phalangeal joint. If we look for any marking in the sole produced by opposition or adduction of the great toe in man we look in vain. There is no such marking, and therefore the characteristic mark found in the palm bounding the thenar eminence is wanting in the sole. We find, however, a curved line across the sole beginning at the base of the second digit and running at first somewhat longitudinally for a short distance and then curving outwards to end at the outer border of the foot. This curved line is often interrupted in the sole, but can always be readily distinguished. It is frequently spoken of as limiting the ball of the little toe, but it too is opposite the metatarso-phalangeal joint and is therefore merely an indication of the flexion of the smaller toes at that



From a photograph of the sole of the foot of a girl nine years of age, showing the markings on the sole of the human foot.



From a photograph of the sole of the foot of the Orang Outang, showing the markings on the integument of the sole.

point. It frequently joins the curve described at the base of the great toe. The great obliquity of this groove in the human foot is due not to the fact that the toes flex towards the great toe (compare the description of the hand) but to the fact that the metatarsal bones of the toes become progressively shorter as we proceed to the fifth digit, the groove in question lying over the heads of the metatarsal bones.

Let us now compare the foot of the Orang with that of man. The markings in the sole of the foot in the Orang are more distinct than in man because the animal does not obliterate them in walking, during which the outer margin of the foot alone comes to the ground; the outer margin is in consequence smoother than the remaining portion of the sole. We are at once struck by the great length of the four outer toes, they are long, and are separated from one another so as to resemble fingers rather than toes. The great toe in the Orang's foot, however, presents a remarkable difference from the hallux in man. Thus in the Orang it is very much shorter than the other toes, and its long axis forms a marked angle with the long axis of the remaining part of the foot. It is capable in fact of being placed at right angles to the long axis of the sole. The metatarsal bone of the great toe is not connected by a transverse metatarsal ligament to the second digit, and in this respect also differs from the human foot. The ball of the great toe in the Orang (as observed in the photograph) is marked off by a well marked groove, but this groove is not opposite the metatarso-phalangeal joint but opposite the tarso-metatarsal joint and marks off the mass of muscular tissue which lies in relation to the plantar aspect of the metatarsal bone. In other words the line is associated with adduction and opposition, and in this respect entirely corresponds to the line described in connection with that movement in the human hand or in the hand of the Orang itself. The lines running across the sole at the bases of the other digits are oblique and very similar in their position and characteristics to those observed in the palm of the hand. The obliquity here may partly be accounted for by the gradual diminution in length of the digits as we proceed from the second to the fifth digits, but is also accounted for by the fact that the Orang flexes its toes not directly into the sole, but somewhat towards the hallux, the mark being at right angles to the line of movement in flexion. The lines corresponding to the flexion of the digits themselves are well marked opposite the metatarso-phalangeal and the interphalangeal joints. Note that in the Orang the line indicating flexion of the hallux at the metatarso-phalangeal joint is well marked, but is separated from the sole proper and lies upon the plantar aspect of the hallux itself, differing thus in its position and relation to the sole as compared with the condition on the human foot but nevertheless corresponding to the curved line at the base of the so-called ball of the great toe in man. A few longitudinal grooves are observable on the sole of the Orang ; these are due to adduction of the digits towards one another.

It will thus be observed that in studying the foot of the Orang it bears more resemblance to a hand than a foot. In fact as an instrument for grasping objects it is much more serviceable than the hand of the same animal. The hallux is more strongly developed than the pollex, and the movements of opposition and adduction are much more strongly carried out by the foot than by the hand. The Orang could grasp a sphere with the foot much more readily than with the hand. If, therefore, we were to restrict our considerations to the markings in the integument, as indicating the use to which the member is put, we might be led to conclude that the posterior extremity of the ape ended in a hand and not in a foot. On the other hand, as we shall observe later, when we proceed to describe the dissection of the creature we shall be forced to admit that morphologically the structure in question is a foot and in no sense a hand. We shall take an opportunity of referring again to this subject after the anatomy of the soft parts has been described.

Concerning the manner in which the Orang uses its hands and feet in progression one may quote Huxley's remarks. He says : " it very unwillingly assumes the erect posture, perhaps never in its native haunts. When it walks upon the ground it swings itself along by its very long arms as with crutches, not resting exactly on the knuckles, as the great African apes, but with the inner edge of the index finger on the ground and the thumb spread out. The hind foot does not come flat to the ground, but rests upon its outer edge with the toes close together and curved. Even when passing from bough to bough of the trees among which its life is chiefly spent, it observes a remarkable slowness and caution in its movements."[1]

The Myology of the Extremities.

The *Trapezius* arose from all the dorsal spines, from the ligamentum nuchae and, by an origin 2 cm. wide from the occipital bone. It was inserted into the outer third of the clavicle, the acromion process and

1 Loc. cit. Vol. I, p. 564.

2 My colleague, R. D. Rudolf. M.D., Edin., dissected the rightside of the Orang, and noted in detail the connections and relations of the muscles of the fore and the hind limbs. I have noted throughout my paper those points in which Dr. Rudolf's account differed from the results obtained by me in the dissection of the left side of the animal.

the spine of the scapula. A branch of the spinal accessory nerve was traced to the muscle. The shortness of the fibres of the trapezius muscle in that part of it which extended from the spine of the scapula to the occiput, and also of the fibres of the levator anguli scapulæ, has already been noted as accounting to some extent for the shortness of the neck in the Orang.

The *Latissimus dorsi* arose from the spines of the lower four dorsal vertebræ and the supra-spinous ligament, also from the lumbar aponeurosis and from the iliac crest extending as far forwards as the anterior superior iliac spinous process. There was thus no "triangle of Petit" as the latissimus dorsi overlapped the external oblique muscle of the abdominal wall at its insertion into the iliac crest. The muscle was inserted into the humerus in front of the teres major, but at a somewhat higher level than that muscle. From the latissimus dorsi, near its insertion, there arose from its tendon a strap-like muscle band (1.5 cm. wide), which proceeded down the arm to be inserted into the fascia attached to the internal condyle and the supra-condyloid ridge of the humerus. This has been called by Bischoff the *Latissimo-condyloideus.* Another muscular slip derived from the latissimus dorsi passes on a plane posterior to the main part of the muscle, and also behind the slip passing to the internal condyle, to be inserted along with the lower part of the teres major muscle into the humerus. This slip to the teres major muscle was found by Hepburn[1] in both the Chimpanzee and the Orang. The latissimo-condyloideus or *Dorso-epitrochlearis*, as it has been designated by some authors, occurs in all apes, not only in anthropoid apes, but in all apes lower in the scale. It is therefore a characteristic muscle of the ape and is always present in these creatures, whilst in man it is absent, or only occurs occasionally in a very rudimentary form. Thus in man one finds that a muscular slip is occasionally given off from the latissimus dorsi and passes downwards to the long head of the triceps, to the fascia, or to the internal intermuscular septum of the arm (Quain[2]); this, it is claimed, corresponds to the latissimo-condyloideus of the ape.

The *Rhomboideus* muscle in the Orang formed a continuous sheet arising from the dorsal spine as low as the sixth vertebra, and from the ligamentum nuchae, also receiving a very definite slip of origin from the occipital bone—the occipital attachment was 2.5 cm. wide. This occipital portion, although showing a continuous line of origin with the part

1 David Hepburn, "The Comparative Anatomy of the Muscles and Nerves of the Superior and Inferior Extremities of the Anthropoid Apes," Journ. of Anat. and Phys., Vol. XXVI, 1892, p. 152.

2 "Quain's Elements of Anatomy," edited by Schäfer and Thane, Vol. II, part 2, 1892, p. 205,

arising in the middle line of the back, was somewhat separated from the latter by a narrow interval, which is indicated in the drawing (plate III, fig. I, *rhom*). The two portions, occipital and spinal, united to form a continuous insertion into the whole of the vertebral border of the scapula, the upper part lying on the dorsal aspect of the levator anguli scapulæ where the latter muscle was inserted into the scapula. The occipital origin is not constant in the Orang, as Fick[1] found that in his specimen the muscle did not arise higher than in man. On the other hand, Bischoff, Owen and others have described an occipital origin in the Orang, and it appears to occur also in the lower apes. Macalister failed to find it in a young female Gorilla dissected by him. There was no occipital attachment described by Duvernoy in the Gorilla.[2] In man one finds that the occipital attachment occurs as an occasional variety.

The *Levator anguli scapulæ* (plate III, fig. I, *l.a.s.*), arose by three slips from the transverse processes of the upper three cervical vertebræ, and was inserted into the upper angle of the scapula and into its vertebral border, lying there in the deep aspect of the rhomboid muscle. At its insertion it was closely incorporated with the serratus magnus muscle. In an Orang dissected by Fick[3] the origin of the muscle extended as low down as the transverse process of the seventh cervical vertebra.

The *Serratus Magnus* arose by eleven digitations from the upper eleven ribs, taking its origin from the anterior extremities of the osseous ribs, and in its lower portion interdigitating with the external oblique muscle of the abdomen. It passed backwards to be inserted into the whole of the vertebral border of the scapula, blending there with the levator anguli scapulæ as already described.

The two muscles last described are closely related to one another; it will be observed that when the levator anguli scapulæ arises from the complete series of cervical vertebræ (as in Fick's Orang), the muscle becomes necessarily almost continuous at its origin with the serratus magnus, and as we have already observed they are united at their insertion. Thus an almost continuous sheet of muscle is formed. In man the muscles are wholly separate, the one in the neck and the other in the thorax. These observations led Bischoff[4] to conclude that in the

1 Loc. cit., p. 19.

2 Loc. cit., p. 76.

3 Rudolf Fick, 2. "Beobachtungen an einem zweiten erwachsenen Orang-Utang und einem Schimpansen." Archiv für Anat. und Phys., Anat. Abt., 1895, p. 297.

4 Bischoff, "Beiträge zur anatomie des Hylobates leucisus und zu einer vergleichenden Anatomie der Muskeln der Affen und des Menschen." Abhandl. der math.-phys. Classe der könig. bayer. Akad. der Wissenschaften, Vol. X, 1870, p, 207.

ape we had definite proof that the two muscles belong to one another and form one single great muscle going from the ribs in the chest and from the cervical vertebræ in the neck to be inserted into the whole length of the vertebral border of the scapula. Bischoff states that in Macacus and other lower apes, this continuity of the two muscles is even more complete than in anthropoids ; in these a bundle arises from the first rib, which unites immediately with that arising from the seventh cervical vertebra, whilst in anthropoids a space exists between the two portions as a rule. One must remember, however, that the extensive origin described from the cervical vertebræ does not always exist in the Orang, as in my specimen there were only three slips of origin from the three upper cervical vertebræ. Hepburn[1] describes four slips in the Orang dissected by him. In man there occasionally occurs partial union between the two muscles in question (Quain), whilst the origin of the levator may be extensive, receiving aponeurotic fibres even from the first and second ribs (Testut).

It would therefore appear that, as a rule, the two muscles are distinct in man ; they are continuous in the lower apes, and the higher (anthropoid) apes occupy an intermediate position where there is a partial continuity.

The *Omo-cervicalis* (plate III, fig. I, *m.o*), is an interesting muscle which Bischoff asserts is not found in man,[2] at all events of similar character to that occurring in apes. It arose in my Orang from the anterior aspect of the arch of the atlas vertebra and from its transverse process ; it was inserted into the clavicle on its posterior aspect at the junction of the middle and outer thirds of the bone, the attachment to the clavicle being 1.5 cm. wide. The muscle has been described in the anthropoid apes and in the lower apes by Huxley,[3] whilst in the various anthropoids it has been found by Cuvier,[4] Vrolik,[5] Owen,[6] Chapman,[7] Macalister,[8] and others. Its attachment to the shoulder girdle varies in apes and

1 Loc. cit., p. 153.

2 Loc. cit., p. 207.

3 Loc. cit., Vol. I, pp, 428, 456, 528, 596, 647, and Vol. II, p. 40.

4 Georges Cuvier, "Anatomie comparée ; recueil de planches de myologie," Paris, 1849.

5 Loc. cit., p. 18.

6 R. Owen. "Myology of Simia Satyrus," Proceedings of the Zoological Society of London, Part I, 1830–31, p. 29.

7 H. C. Chapman, "On the Structure of the Orang-Outang," Proceedings of the Academy of Natural Science of Philadelphia, 1880, p. 161.

8 Alex. Macalister. "The Muscular Anatomy of the Gorilla," Proceedings of the Royal Irish Academy, Sr. 2. Vol. I, 1870-74, p. 501.

hence Bischoff suggested the name of "omo-cervicalis" and abandoned the old names of "cleido-cervicalis" and "acromio-trachealis" which had been applied to it. Tyson called it "levator claviculæ." Bischoff asserts that in all four anthropoids it always arises from the clavicle, whilst in Cynocephalus it has been found arising from the acromion process and in Macacus from the spine of the scapula. Deniker[1] demonstrated the muscle in a foetal Gorilla of the fifth or sixth month of gestation, and in a foetal Gibbon of the seventh or eighth month ; in both instances passing from the atlas vertebra to the clavicle. It would appear that the atlantal attachment of this muscle is very constant in anthropoid apes, although Champneys[2] described the dissection of a Chimpanzee in which the muscle arose "from the occipital bone in a line with the occipital condyles and was inserted into the acromial or external half of the clavicle anterior to the insertion of the trapezius." Huxley states that in man[3] a separate muscle has been seen to pass from the mastoid process to the extremity of the acromion, detached from the trapezius, and representing, to a certain extent, in man the trachelo-acromial. Testut[4] mentions a muscle described by Gruber under the name of "trachelo-clavicularis imus" arising from the transverse process of the sixth cervical vertebra, and inserted into the clavicle. This Testut considers a variety of the omo-cervicalis. In Quain's Anatomy[5] is mentioned a detached bundle of the levator anguli scapulæ passing from the transverse process of the upper one or two cervical transverse processes to the outer end of the clavicle ; this would apparently represent a true omo-cervicalis in man.

We may conclude, therefore, that the muscle in question is found invariably in the ape, whilst in man it occurs as a very rare variety.

The *Omo-hyoid* muscle was present and possessed similar attachments and relations to those in man. The supra-scapular artery and nerve passed over the superior border of the scapula anterior to the omohyoid insertion. There was no indication of a transverse ligament which exists over the supra-scapular notch in man. In Fick's[6] Orang the omo-hyoid was weak and there was no intermediate tendon.

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1 J. Deniker, "Recherches anatomiques et embryologiques sur les singes anthropoïdes jeunes et adultes," Archives de Zoologie expérimentale, Sr. 2, Vol. III, 1885, pp. 125, 131.

2 F. Champneys, "On the Muscles and Nerves of the Chimpanzee (Troglodytes niger) and a Cynocephalus anubis," Journ. of Anat. and Phys., Vol. VI, 1872.

3 Loc. cit., Vol. I, pp. 428, 456.

4 Loc. cit., Vol. I, Part 2, p. 697.

5 Loc. cit., Vol. II, Part 2, p. 208.

6 Loc. cit., I, p. 15,

Bischoff[1] also remarks upon the fact that the intermediate tendon often fails to develop in the ape; in Bischoff's Orang, however, the whole muscle failed. This authority also refers to an Orang dissected by Alix in which the omo-hyoid arose from the clavicle as well as from the scapula; this variation in the Orang is of interest, because a similar variation sometimes occurs in man. The total absence of the omo-hyoid is not rare in man; of this Testut[2] has recorded nine cases. Again the absence of either the anterior or posterior belly may occur, and the bony attachment more particularly of its posterior belly is subject to great variation in man. Gegenbaur,[3] after a critical study of the varieties of the omo-hyoid as it occurs in man, and the conditions of its development met with in the lower animals, concludes that it belongs to a muscle group including in man the sterno-hyoid and sterno-thyroid muscles. These muscles in some animals (reptiles) form a continuous attachment from the sternum, along the clavicle to the scapula. Referring the omo-hyoid to such a group of muscles we can readily explain the occurrence of the intermediate tendon and the variation in the bony attachments, sometimes to the clavicle, sometimes to the scapula, or it may be to both bones.

The *Sterno-mastoid* had an extensive origin from the mastoid process and the occipital bone, and was inserted by two heads, one into the manubrium sterni on its anterior aspect, and the other into the inner fourth of the clavicle. Cuvier[4] figures the sterno-mastoid in the Orang as two very distinct muscles, the clavicular portion arising from the skull below the sternal portion and proceeding to its insertion into the clavicle. In the Gorilla it is usually in two distinct portions, as indeed it is also in the other anthropoids. The two portions of the sterno-mastoid in man are separated from one another by a varying interval at their insertion.

The *Pectoralis major*, consisted of three very distinct portions :—(1) *Pars costo-abdominalis* (plate IV, fig. 2, *p.m. 1*), which arose from the osseous part of the fifth rib near its sternal extremity, and by an origin 4 cm. wide from the aponeurosis of the external oblique muscle of the abdomen. The fibres passed very obliquely upwards and outwards and lay on a plane posterior to the other two portions of the muscle. The insertion was into the strong fascia over the biceps tendon, and

1 Loc. cit., I, p. 205.

2 Loc. cit., Vol. I, Pt. 2, p. 677.

3 C. Gegenbaur, "Ueber den Musculus Omohyoïdeus und seine Schlüsselbeinverbindung." Morphologisches Jahrbuch, Vol. I, 1876, p. 264.

4 Loc. cit., plate 15.

extended up to the greater tuberosity of the humerus and the capsule of the joint—the insertion extended further up on the humerus than the other two portions of the muscle. (2) *Pars sterno-costalis* (plate IV, fig. 2, *p.m. 2*), arose from the cartilages of the third, fourth, fifth and sixth ribs, and from the adjacent portion of the anterior aspect of the sternum. It was inserted by means of the strong fascia over the biceps tendon into the humerus. The fibres of this portion of the muscle passed almost horizontally from origin to insertion. It lay intermediate in position between the pars costo-abdominalis and the pars sternalis. (3) The *Pars sternalis* (plate IV, fig. 2, *p.m. 3*), arose from the anterior surface of the manubrium sterni near its upper margin. There was no attachment to the clavicle. The fibres passed very obliquely from above downwards and outwards in front of the other portions of the muscle. The muscle was inserted into the humerus on the anterior aspect of the bone in front of the biceps by an insertion 2 cm. wide, extending further down on the bone than the other portions of the muscle. The three portions of the pectoralis major were very definitely separated from one another, the intervals being filled in by a large amount of fat.

The other three anthropoid apes, according to Bischoff, possess a fourth division of the pectoralis major, viz., a " pars clavicularis " arising from the sternal end of the clavicle, whilst in an Orang dissected by Bischoff[1] the clavicular portion was, as in my specimen, absent. On the other hand Fick[2] describes a clavicular portion in both Orangs dissected by him, and Bischoff[3] found in a second Orang examined by him, a portion of the pectoralis major arising from the ligaments of the sterno-clavicular joint. Chapman and Owen both failed to find a clavicular portion in the Orang. Bischoff, it may be added, is authority for the statement that the pars clavicularis fails in the lower apes.

It would therefore appear that the pectoralis major muscle is composed of four portions ; this fact is recognized by Testut in describing the muscle in man as consisting of : 1st, portion claviculaire ; 2nd, portion sternale ; 3rd, portion abdominale ; 4th, portion chondro-costale. The clavicular portion, which is, as a rule, well developed in man, is

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1 Loc. cit., I, p, 208.

2 Loc. cit., I, p. 15 and 2 p. 298.

3 Bischoff, "Beiträge zur Anatomie des Gorilla," Abhand. der math.-physik. Classe der könig. bayer. Akad. der Wissenschaften, Vol. XIII, Abth. 3. München, 1880, p. 9.

4 Loc. cit., p. 161.

5 Loc. cit., p. 29.

6 Loc. cit., Vol. I, pt. 2, p. 722.

present only occasionally in the Orang, and is absent in the lower apes. On the other hand, the Gorilla, Chimpanzee, and Gibbon resemble man in the well-developed clavicular portion of this muscle ; in the Gorilla, in fact it is more strikingly developed than in man. One notices in man considerable variation in the width of the interval separating the clavicular portion of the muscle from the remaining part ; according to Testut this may be several centimetres. One is inclined to believe that the portion in the Orang which I have described as the "pars sternalis" in reality corresponds to the "pars clavicularis" of man (see plate IV, Fig 2, *p.m. 3*). My reason for coming to this conclusion is that we have in the anterior part of the "pars sterno-costalis" in my Orang a portion corresponding to the "pars sternalis" of man, whilst the wide interval existing in my Orang between the middle and upper portions of the muscle would correspond to the varying interval observed in man between the sternal and clavicular portions of the muscle. It would appear, therefore, that the upper portion of the great pectoral has gradually extended its width of attachment, and has also travelled outwards. At first purely sternal (as in the lower apes) then having a varying degree of clavicular attachment. In the case of Bischoff's Orang, quoted above, the attachment was intermediate in position, namely to the sterno-clavicular joint. One may note that in man the muscle may extend along the clavicle and become incorporated with the deltoid or, on the other hand, in rare cases, the clavicular portion may be absent (Quain). In my Orang a large triangular interval existed between the anterior border of the deltoid and the superior border of the pectoralis major and the clavicle ; this space was crossed by the pectoralis minor.

In connection with the pectoralis major in man, various anomalous muscles have been described. In a female subject Bryce[1] has recently reported the following anomalous development of the pectoral sheet. The upper part of the pectoralis major muscle was ill-developed, being represented by a narrow band resembling in fact, very much, the pars sternalis which I have described in my Orang. He found present also a "sterno-clavicularis" which arose from the side of the manubrium sterni and the second costal cartilage, and was inserted into the clavicle along the inner two-thirds of the bone. A "sternalis" attached partly to the second cartilage and the tendon of the sterno-clavicularis above, and below to the aponeurosis of the external oblique opposite the seventh cartilage, and a "chondro-epitrochlearis" which arose from the outer end

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1 T. H. Bryce, "Note on a Group of Varieties of the Pectoral Sheet of Muscle." Journ. of Anat. and Phys., Vol. XXXIV, 1899, p. 75.

of the sixth costal cartilage running under the lower border of the pectoralis major, it passed down the arm and was inserted into the intermuscular septum two inches above the internal condyle.

The *Pectoralis minor* (plate IV, fig. 2, *p. min*), arose from the bone of the fourth rib by an origin 2 cm. wide. immediately external to the cartilage, and from the bone and cartilage of the third rib by an origin of similar width. The muscle was inserted into the superior and inner part of the coracoid process of the scapula. Certain fibres of the tendon of insertion were carried on beyond the coracoid and were definitely traced as two ligamentous structures which diverged from one another, one of which was attached to the outer end of the clavicle, and the other into the acromion process of the scapula (see plate IV, fig. 2, and fig. 3, *lig. 1*, *lig. 2*), the insertion here described has not hitherto been demonstrated, and it would appear to be an observation of some interest. Duvernoy[1] states that in the Chimpanzee the pectoralis minor became attached to the coraco-clavicular ligament; again whilst I found no description of an acromial attachment among the anthropoid apes I find that in Cynocephalus, according to Bischoff[2] the pectoralis minor is inserted into the coracoid process and the coraco-clavicular ligament. In the Chimpanzee we find that Huxley, Fick, Bischoff, Hepburn and others have described an insertion into the capsule of the shoulder joint. It is not unusual to find this capsular attachment in man. This relation of the pectoralis minor to the capsule, in certain cases occurring in man and monkeys, induces Bland Sutton to believe that the coraco-humeral ligament of the shoulder joint is the tendon of the pectoralis minor muscle transformed into a fibrous band. But as the insertion varies so greatly in apes it would seem that Bland Sutton is not warranted in coming to the conclusion he does. Hepburn found that in the Gibbon in addition to a coracoid and a clavicular attachment, the muscle was inserted into the common tendon of the coraco-brachialis and biceps a short distance below the tip of the coracoid process. Whilst in the Chimpanzee both Huxley[5] and Hepburn describe the muscle as uniting with the supra-spinatus. Judging from the attachments described in my Orang, and from the relations found in some other apes and the variations in man, it may be that the trapezoid portion of the coraco-clavicular ligament and the coraco-acromial ligament are in part derived

1 Loc cit., p. 76.

2 Loc. cit., I, p. 209,

3 J. Bland Sutton, "Ligaments, their Nature and Morphology." London, 1887, p. 71.

4 Loc. cit., p. 154.

5 Loc. cit., Vol. I, p. 456.

from the tendon of the pectoralis minor. Wood[1] has described in man a case in which the muscle joined the coraco-acromial ligament and another in which it was inserted into the clavicle and the costo-coracoid membrane.

The *Serratus magnus* arose from the upper eleven ribs, interdigitating below with the external oblique muscle of the abdomen and was inserted into the whole length of the vertebral border of the scapula, blending above with the levator anguli scapulæ at its insertion. Fick describes an origin in the Orang from twelve ribs. In man the muscle rarely extends beyond an attachment to the upper nine ribs.

The *Deltoid* arose from the outer third of the anterior surface of the clavicle, from the acromion process and from the spine of the scapula also from the fascia over the infra-spinatus muscle. It was inserted into the outer aspect of the humerus as in man; some additional slips pass to the humerus for about 2 cm. above the main point of insertion, and some superficial fibres pass to the fascia, which extends down to the external condyle. Fick speaks of this muscle as similarly well developed in his Orang.

The *Teres major* arose from the lower fourth of the axillary border of the scapula and from the dorsal surface of the inferior angle; its insertion 3cm. wide found attachment to the humerus behind the latissimus dorsi. The lower part of the muscle near its insertion was joined by the slip from the latissimus dorsi already described (p. 21).

The *Teres minor*, the *Supra-spinatus* and the *Infra-spinatus* muscles had similar attachments to those found in man; it was noted, however, that the aponeuroses of insertion of the last two muscles were directly continuous with one another and blended with the capsule of the shoulder joint.

The *Subscapularis* resembled that found in man. Fick described a slip of origin of this muscle from the teres major.

The *Subclavius* was not strongly developed, measuring only 0.3 cm. in width; it arose from the cartilage of the first rib, and had an insertion 2 cm. wide into the clavicle at the junction of the middle and the outer thirds of that bone on its under aspect; it here extended to the point of attachment of the coraco-clavicular ligament, but was in no manner continuous with that structure. The subclavius is poorly developed in

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1 J. Wood, "Variations in Human Myology." Proceedings of the Royal Society of London, Vol. XV, 1867, p. 231.

the anthropoid apes; in Huxley's Gorilla[1] it was only represented by a ligament.

The *Triceps* muscle had the following origin:—1. The long head arose from the upper two-thirds of the axillary border of the scapula to the extent of 4 cm.. The upper part of its origin being in front of the teres minor and the lower part behind the teres major. 2. The inner head arose from the posterior aspect of the humerus a short distance above and behind the lowest point of attachment of the teres major. The musculo-spiral nerve crosses this head obliquely about 2.5 cm. below its upper limit; the nerve is thus separated from the bone by the muscle. 3. The external head arose from the posterior aspect of the humerus as high up as the insertion of the teres minor. The musculo-spiral nerve proceeds outwards between the lower part of this muscle and the bone. The triceps possesses a very wide fascial insertion in the region of the elbow, and is inserted also into the olecranon process. Fick remarks upon the striking weakness of the inner head in his Orang.

The *Coraco-brachialis* arose from the anterior portion of the coracoid process, and from the fascia over the subscapularis muscle; two portions of the muscle were defined, one found insertion by an attachment 2.5 cm. wide into the middle of the inner portion of the humerus, whilst a more feebly developed upper portion found an attachment by an insertion 0.5 cm. wide immediately above the other portion. The two parts are separated by the passage of the musculo-cutaneous nerve, which sends a branch of nerve supply to each. Some fibres from the upper portion pass down in front of the tendinous insertion of the lower part, and there find independent insertion into the humerus. Wood by a comparative study of this muscle in the mammalia concludes that the coraco-brachialis is made up of three component parts: 1. The *coraco-brachialis brevis*, which passes from the outer side of the coracoid process near its root, to the capsule of the shoulder-joint near the anatomical neck of the humerus ; 2. The *Coraco-brachialis medius* obtaining its insertion into the inner border of the humerus near its middle ; 3. The *Coraco-brachialis longus*, which extends down the inner side of the arm to be attached to the internal condyle. The coraco-brachialis medius is the portion of the muscle which is characteristically of human type; in man also, both brevis and longus occur as varieties, the latter being the

1 Loc. cit.. Vol. I, p. 538.

2 John Wood, "On Human Muscular Variations, and their Relation to Comparative Anatomy. Journ. of Anat. and Phys., Vol. I, 1867, p. 45.

more common. Vrolik[1] describes the medius and longus as existing in the Chimpanzee, a condition which also existed in Hepburn's Orang. The degree of development of this muscle is, however, by no means constant, but, according to Bischoff, numerous variations occur both among the anthropoid apes and among the lower apes. In certain of the mammalia, according to Wood, the brevis alone is developed as in the dog and cat, also in bats and moles. Bland Sutton[2] compares the arrangement of the coraco brachialis in its three parts in the arm to the arrangement of the three adductor muscles in the thigh.

The *Biceps* resembled, in its two heads of origin, the condition found in man ; it was inserted into the radius by an aponeurosis of insertion 1.5 cm. wide, very thin and ribbon-like as it passed back into its insertion, which lay wrapped around the neck of the radius when the forearm was pronated. A well-developed bicipital fascia passed off to blend with the fascia on the inner border of the forearm. This fascia was absent in Fick's Orang. Bischoff[3] states that in all apes (anthropoids and others) the biceps arises as in man, with the exception of the Gibbon, where he found that the short head arose from the lesser tuberosity of the humerus instead of from the coracoid process ; Huxley[4] found in his Gibbon, the short head arising from the tendon of the pectoralis major. The muscle is subject to great variation in man chiefly in the multiplication of additional heads of origin: the long head has occasionally been absent, as described by Lubosch[5] and others in man, but such a defect is extremely rare.

The *Brachialis anticus* arose from the anterior portion of the humerus as high up as the insertion of the deltoid, the origin of the muscle being wholly external to the insertion of the coraco brachialis. It was inserted into the coronoid process of the ulna. A narrow slip from the outer aspect of this muscle crossed in front of the musculo spiral nerve and joined the supinator longus. This connection with the supinator longus has been observed in man (Testut).

The *Pronator radii teres* arose by two heads, one from the internal condyle and the intermuscular septum, and the other from the coronoid process of the ulna on its inner aspect. The median nerve passed into

1 Loc. cit., p. 30.

2 Loc. cit.. p. 13.

3 Loc. cit. 1, p. 210.

4 Loc. cit., Vol. I, p. 648.

5 W. Lubosch. "Ein M. Coraco—Antibrachialis beim Menschen Beiträge zur Morphologie des M. Biceps Brachii." Morphologisches Jahrbuch, Bd. XXVII, Heft 2, 1899, p. 309.

the forearm between its two heads, the deep head separating the nerve from the ulnar artery. It was inserted into the radial border of the radius by an insertion 2 cm. wide immediately below the upper third of the bone. The high insertion of the pronator radii teres corresponds to that found by Langer[1] in his Orang. This, he points out, differs from the condition found in man, where the muscle in question is inserted below the middle of the bone. It also implies a shorter extent of attachment of the supinator brevis, which is attached above the pronator. This circumstance led Langer to assert that it is only the lower part of the radius which is so enormously elongated in the Orang compared with the condition found in man. Langer's Orang was young, but in the adult animal dissected by Fick[2] he found the position of the insertion of the pronator similar to that occurring in man; he therefore concludes that either the high insertion is characteristic of the young Orang thus differing from the old animal, or that Langer's case was abnormal—my specimen would go to prove the truth of the former hypothesis. In Bischoff's Gorilla the coronoid head of the muscle was absent, but Macalister[3] found it in his specimen. Chapman[4] found both heads in the Orang. The coronoid head is frequently absent in man (Testut).

The *Flexor carpi radialis* arose from the common origin of the flexors from the internal condyle and the intermuscular septum, also from an oblique line on the outer border of the radius in common with the flexor sublimis digitorum; it was inserted into the base of the second metacarpal bone, after passing through the groove in the trapezium. Fick and Langer both describe a radial origin in the Orang. The radial head occurs as an occasional variation in man.

The *Palmaris longus* arose in common with the other flexors from the internal condyle and from the fascia over it. It lay immediately subjacent to the fascia of the forearm until it reached a point 3 cm. above the wrist joint, where it perforated the fascia and continued down upon its superficial aspect. Crossing the anterior annular ligament it proceeded to its insertion into the palmar fascia. There is a very definite slip to the base of the thumb, and from this the abductor pollicis arises in part. In both Orangs dissected by Fick there was a slip to the abductor pollicis and he describes, in addition, another slip to the flexor minimi digiti. Bischoff states that the palmaris longus was absent in the

1 Loc. cit., p. 179.

2 Loc. cit. 1, p. 22.

3 Loc. cit., p. 502.

4 Loc. cit., p. 162.

Gorilla, and the result of Hepburn's investigations was that he found this muscle present in the Chimpanzee, Orang and Gibbon, but absent in the Gorilla.

The palmaris longus, both in man and apes, would appear to be a rudimentary structure; in many animals it is a well developed muscle and sends tendons to all the digits. From a comparative study of this muscle Bland Sutton[1] and others have arrived at the conclusion that the palmar fascia of the human hand arises from the degeneration of the distal end of the palmaris longus muscle. According to Grapow[2] the palmar fascia was first described as an expansion of the palmaris longus by Dupuytren in 1832. The view which Grapow holds concerning it is, that the main part of the palmar fascia is derived as a prolongation of the anterior annular ligament of the wrist, whilst the superficial, longitudinally coursing fibres are derived from the palmaris longus muscle. The muscle in man is very variable in its development, it is entirely absent in ten per cent. of all cases, and it presents great variety, not only in its points of insertion but also in the development of its fleshy and tendinous fibres.

The *Flexor carpi ulnaris* arose in common with the flexors from the internal condyle, also from the inner side of the olecranon process of the ulna. The ulnar nerve passed into the forearm between the two heads. It was inserted into the pisiform bone. The muscle thus resembles that found in man.

The *Flexor sublimis digitorum* vel *Perforatus* arose from the common origin from the internal condyle and intermuscular septum, also from the coronoid process and the olecranon process and in common with the flexor carpi radialis from the oblique line of the radius. Passing beneath the annular ligament it there passed into the palm in four tendons. The tendon for the index finger and that for the little finger were derived mainly from fibres arising from the internal condyle. The tendon for the middle finger was derived mainly from fibres arising from the radius. The tendon for the ring finger was derived mainly from fibres having an origin from both the radius and the internal condyle. The fleshy mass from which the tendon for the index finger arose formed a very definite fasciculus which passed down on the deep aspect of the main part of the muscle along its ulnar border, and

1 Loc. cit., p. 16.

2 Max-Grapow, "Die Anatomie und Physiologische Bedeutung der Palmaraponeurose. Archiv für Anatomie und Entwickelungsgeschichte, 1887, p. 145.

then crossed obliquely behind the other tendons to reach the index finger. The fasciculus is joined at an acute angle by a few fibres from the radial origin; this radial fasciculus represented not more than one-twentieth part of the main fasciculus, being a very slender, though definite contribution. In Bischoff's Gorilla there were four almost completely separated muscles having an arrangement similar to that found in my Orang. This differs from the muscle dissected by Fick in his Orang, in which there was a superficial fasciculus passing to the fourth and fifth digits, and a deep fasciculus to the second and third digits. The muscle in man is developed in two layers, more or less separable from one another, the superficial passing to the third and fourth, and the deep to the second and fifth digits.

The *Flexor profundus digitorum* vel *Perforans* arose by three distinct fasciculi.

1. From the anterior and inner aspects of the ulna extending back to the posterior border and upwards as high as the posterior portion of the olecranon process, and downwards on the ulna to about its middle. (The nerve supply was from the ulnar.)

2. From the anterior aspect of the ulna up to and including the lower part of the coronoid process ; from the anterior and inner border of the ulna below the fasciculus I. and from the interosseous membrane. (The nerve supply was the median.)

3. From the anterior aspect of the radius, and from the interosseous membrane ; this radial attachment extends two-thirds of the way down the bone. In the middle third, well over to the radial border, its attachment is limited by the origin of the flexor sublimis digitorum. (The nerve supply was from the median.)

The tendons passed under the annular ligament, and fasciculus No. 1 supplied tendons to the minimus and the ring fingers ; fasciculus No. 2 to the middle finger, and fasciculus No. 3 to the index finger. A *lumbrical* muscle was developed on the radial side of each tendon in the palm. Rudolf traced the nerve supply of the lumbricals, and found the outer two were supplied by the median and the inner two by the ulnar nerve.

There was no trace of a long flexor for the thumb. In this particular man differs very markedly from the Orang. In man the *flexor longus pollicis* is a separate well developed muscle, and nothing approaching it is found in the ape. Langer,[1] Fick,[2] Bischoff,[3] Huxley,[4] Chapman,[5] and others have failed to find a trace of the flexor longus pollicis in the Orang. Duvernoy, in the Gorilla, describes the flexor as going to the index finger and from this a slender tendon is detached for the thumb, which takes the place of the flexor longus pollicis.[6] Brooks[7] in dissecting an Orang found that the two heads of the flexor brevis pollicis were separated at their insertion by a slender tendon which, he considered, represented the flexor longus pollicis; this tendon was inserted into the ungual phalanx, and it could be followed up the forearm, but about two inches above the wrist it expanded into areolar tissue. Among the anthropoids one finds a rudimentary tendon going to the thumb, this is derived from the flexor tendon which is distributed to the index finger. Thus in the Chimpanzee, Huxley and Macalister both describe a very slender tendon to the thumb from the flexor longus digitorum tendon for the index finger. A similar condition is found by Bischoff and others in the Gorilla and the Gibbon. Among the lower apes of the old world (Cynopithecini) Huxley found a rudimentary slender tendon to the pollex derived from the flexor tendon to the index, a condition similar to that in the anthropoids named. Among the Lemurs (Stenops tardigradus) the same authority states,[8] that a true and distinct flexor longus pollicis of separate origin and insertion exists. Similar observations have been made by Bischoff regarding the lower apes and the rudimentary condition in them of the flexor longus pollicis. The anthropoid apes and the lower apes therefore resemble one another in respect to this muscle, whilst they all differ from man where the flexor longus pollicis is developed as a strong muscle completely separated from the flexor profundus digitorum, a condition never yet found in the ape. It is not common to find much variation in the development of the flexor longus pollicis in man, but such does occur occasionally. Turner[9] placed on record several cases in which the flexor longus pollicis contributed a tendon of communication

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1 Loc. cit., p. 180.

2 Loc. cit. I, p. 23.

3 Loc. cit. I, p. 214.

4 Loc. cit., Vol. I, p. 596.

5 Loc. cit., p. 162

6 Loc. cit., p. 106.

7 H. St. John Brooks, "On the Short Muscles of the Pollex and the Hallux of the Anthropoid Apes with Special Reference to the Opponens Hallucis." Journ. of Anat. and Phys., Vol. XXII, 1887-8, p. 82.

8 Loc. cit., Vol. II, p. 145.

9 W. Turner, "On Variability in Human Structure, with illustrations from the Flexor Muscles of the Fingers and Toes." Transactions of the Royal Society of Edinburgh, Vol. XXIV, 1867, p. 179.

with the flexor profundus digitorum. Schulze[1] has described a similar condition. Turner records one case in which the bond of union passed in the opposite direction from the flexor profundus to the flexor longus pollicis. Wagstaffe[2] has described a case in which a muscle arose like the flexor longus pollicis, but was inserted into the deep flexor tendon to the index finger and was connected also with the fibrous structures about the wrist; there was also a tendon on the palmar aspect of the first and second phalanges of the thumb, which, however, was attached above to the head of the metacarpal bone. Gegenbaur[3] has recorded a case in which the flexor longus pollicis was absent from the thumb of man—the muscle had evidently fused with the flexor for the index finger; the thumb itself was very rudimentary, and presented an appearance very similar to that found in the apes. The abnormality was found on the left side of the body, the right flexor longus pollicis being normally developed. The importance of these facts concerning the absence of the flexor longus pollicis in the ape and its existence as a strongly developed structure in man is emphasized by Testut[4] when he says, "De toutes les dispositions anatomiques qui différencient actuellement l'homme des autres Primates, l'une des plus importantes est, sans conteste, la présence chez l'homme, l'absence chez les Singes d'un long fléchisseur propre du pouce, complètement distinct des autre fléchisseurs." Testut holds that the flexor longus pollicis is present in the apes, arising as it does in man, but the peculiarity in apes is that it fuses with the flexor profundus and loses the characteristic individuality which is found in man where it passes as a distinct and separate muscle to the thumb. Testut himself, after examination of a large number of subjects, had never found the flexor longus completely absent from the thumb of man.

Gratiolet and Alix[5] describe a rudimentary muscle in the Chimpanzee arising from the ligaments over the anterior aspect of the carpus and inserted into the last phalanx of the thumb.

The *Pronator quadratus* consisted of a number of muscle fibres passing transversely from the radius to the ulna; in the upper part of

1 F. Eilhard Schulze, "Die Sehnenverbindung in der Planta des Menschen und der Säugethiere." Zeitschrift für Wissenschaftliche Zoologie, Bd. 17, 1867, p. 1.

2 W. W. Wagstaffe, "Partial Deficiency of the Tendon of the Long Flexor of the Thumb," Journ. of Anat. and Phys., Vol. VI, 1872, p. 212.

3 C. Gegenbaur, "Ein Fall von mehrfachen Muskelanomalien an der oberen Extremität," Virchow's Archiv für Pathol. Anat. und Phys., Vol. XXI, 1861, p. 382.

4 L. Testut, "Le Long Fléchisseur Propre du pouce chez l'homme et chez les Singes," Bulletin de la Soc. Zool. de France, Vol. VIII, 1883, p. 164.

5 Loc. cit., p. 172.

the muscle the fibres were very oblique, arising from the ulna as high up as the upper portion of the lower fourth, and passing obliquely downwards and outwards to the radius. The obliquity of the fibres was also noted by Fick.

The *Supinator longus* arose from the supracondyloid ridge of the humerus as high as the middle of the bone, and extended down to within 2.5 cm. of the external condyle. It was inserted into the outer aspect of the lower extremity of the radius, including the styloid process, the whole insertion being 2.5 cm. wide. In Fick's Orang the insertion began 7 cm. above the styloid process. In the Gibbon, Bischoff found it short, not reaching to the styloid process but inserted into the middle of the bone. A similar condition was found in the Gibbon by Huxley.[1] In man the muscle has been found inserted as high up as the middle third of the radius.

The *Supinator brevis* and *Anconeus* were well developed, and resembled in their connections and relations the condition found in man, in other anthropoids and in the lower apes.

The *Extensor carpi radialis longior* arose below the supinator longus from the supra condyloid ridge of the humerus as low as the external condyle. It passed under the annular ligament in company with the short radial extensor and was inserted into the dorso-radial aspect of the base of the second metacarpal bone.

The *Extensor carpi radialis brevior* arose from the common extensor origin from the external condyle, and was inserted into the dorsal aspect of the base of the third metacarpal bone. The two radial extensors were crossed obliquely by the short and long extensors of the thumb and the extensor ossis metacarpi pollicis ; they resembled in their relations and connections the condition found in man and in the lower and the anthropoid apes.

The *Extensor communis digitorum* arose from the common extensor origin, and passed under the annular ligament in company with the extensor indicis ; it divided into four tendons for insertion into the four inner digits as in man.

The *Extensor minimi digiti* was a very small fasciculus arising in common with the extensor communis ; it was inserted into the extensor expansion over the proximal phalanx of the ring and the little fingers. One finds that the slip to the ring finger occurs as a variety in man,

1 Loc. cit., Vol. I, p. 648.

whilst it would appear to be the usual condition in the Orang, as described by Fick, Bischoff, Huxley, Hepburn and Chapman. On the other hand, according to Bischoff,[1] in the Gorilla, Chimpanzee and Gibbon, and in the lower apes (excluding Cynocephalus, where it exists as in the Orang), the tendon is restricted to the little finger as it is in man.

The *Extensor carpi ulnaris* arose from the common extensor origin, from the olecranon process and the posterior portion of the ulna and from the intermuscular septum ; it was inserted into the ulnar border of the fifth metacarpal bone.

The *Extensor Indicis* arose from the middle of the ulna by an origin 1.5 cm. wide, and from the interosseous membrane, passing beneath the common extensor, it was inserted into the extensor expansion over the dorsal aspect of the proximal phalanx of the second and third digits. In man the extensor indicis is inserted into the index finger only, although, as a variation, it is not very uncommon to find a slip to the middle, or even the ring fingers, whilst occasionally there is a slip to the thumb. It is sometimes altogether absent in man, and Testut[2] states that he has seen it tendinous throughout its whole extent. According to Bischoff[3] in the Gorilla alone among anthropoids do we find the extensor indicis restricted to the index finger and thus resembling man. In the Orang and Chimpanzee it passes to the second and third digits, whilst in the Gibbon it passes to the second, third and fourth digits. In the lower apes also it would appear to be distributed, as a rule, to the second and third digits. Pithecia being an exception (Bischoff), where it is restricted to the index finger only. Huxley,[4] in discussing this muscle in the Orang along with the extensor minimi digiti, calls attention to the fact that the normal arrangement in many of the lower mammalia is to have a superficial and a deep extensor supplied to every digit. This arrangement is approached when as in my Orang the extensor minimi digiti is supplied to the fourth and fifth toes, and the extensor indicis to the second and third toes. These two muscles, as they occur in man, are therefore but fragments of a more extensive muscle group occurring in lower animals.

The *Extensor longus pollicis* arose from the dorsal aspect of the ulna above the origin of the extensor indicis, and passed to its insertion in a

1 Loc. cit. I, p. 212.

2 Loc. cit. I, Vol. I, pt. 2, p. 813.

3 Loc. cit. I, p. 212.

4 Loc. cit., Vol. I, p. 596.

separate compartment of the annular ligament; it was inserted into the second phalanx of the thumb.

The *Extensor brevis pollicis* arose from the interosseous membrane and from the dorsal aspect of the radius and the ulna, it was inserted into the radial aspect of the base of the first metacarpal bone well to the anterior surface. This muscle is absent in most apes. Langer, Fick, Bischoff, Huxley and Chapman failed to find it in the Orang, whilst Hepburn[1] describes the muscle as being inserted, as in my example, into the metacarpal bone. Bischoff states that the muscle is absent in all apes, with the exception of the Gorilla. The muscle in my Orang was quite separate from the extensor ossis metacarpi pollicis, and had a distinct and separate insertion into the metacarpal bone. It represents a condition intermediate between that normal in man and that which Testut says is[2] constant in most apes where, according to this authority, the short extensor is blended with the extensor ossis metacarpi pollicis.

The *Extensor ossis metacarpi pollicis* arose from the radius and ulna, the more extensive attachment being to the radius, and was inserted by two tendons, one of which passed to the trapezium and the other to the fascia, from which the abductor pollicis and opponens arose. On the right side Rudolf found this tendon passing to the metacarpal bone of the thumb. On close examination of the slip to the trapezium one found, close to the point of insertion, a small irregularly oval sesamoid bone about 4 mm. in length. This bone was embedded in fibrous tissue which extended from the styloid process of the radius above to the base of the first metacarpal bone, and was there closely applied to the trapezium immediately below the tubercle of the scaphoid; the fibres of the tendon of the muscle appeared to be inserted into this bone. The sesamoid bone is described by Fick[3] and by Hepburn[4] in connection with the tendon of the extensor ossis metacarpi pollicis in the Orang. Fick describes the muscle as inserted into the trapezium and the first metacarpal on the left side, whilst it had an additional insertion into the scaphoid on the right side of his Orang. Bischoff[5] states that in the Orang, Cynocephalus, Pithecia and Hapale, the muscle is inserted as in man, into the metacarpal bone, whilst in the Gorilla,

1 Loc. cit., p. 167.

2 Loc. cit. 1, Vol. I, pt. 2, p. 811.

3 Loc. cit. 1, p. —,

4 Loc. cit., p. 167.

5 Loc. cit. 1, p. 213.

Chimpanzee, Hylobates, Circopithecus and Macacus it parts into two tendons—one for the trapezium, and the other for the middle phalanx of the thumb. Huxley describes the two divisions of the extensor ossis metacarpi pollicis in all four anthropoids, although he says the division is not so definite in the Orang as in the others.[1] Brooks[2] states that the sesamoid bone is apparently developed in all anthropoids in the tendon of the extensor ossis metacarpi pollicis. The double insertion of this muscle into the trapezium and the first metacarpal bone is frequently found as a variation in man, whilst the occurrence of the sesamoid bone in the tendon of the muscle in question in man has been reported by Zuckerkandl.[3]

The occurrence of the sesamoid bone in the tendon of the extensor ossis metacarpi pollicis has considerable interest attached to it, as Fick has suggested,[4] that it represents a præpollex rudiment. The probability is that the ossicle occurs very constantly in the Orang, although it may be of very small dimensions as Fick[5] found in a second Orang dissected by him, where it was scarcely the size of a grain of rice. Thus it may be very easily overlooked, and requires to be searched for with considerable care. The occurrence of this bone in the tendon of the muscle in question is no new discovery, as it is mentioned and figured by Vrolik[6] in the Orang, and the same writer states that it had been described by Camper in that animal. Camper looked upon it as a ninth carpal bone. Fick is inclined to believe that it does represent a supernumerary carpal bone. He has found it appearing as such in the skeleton of an old female Orang in the Leipzig Zoological Institute, where, on both sides it is attached to the carpus, on the one side being attached by some connective tissue, still unmacerated, to the trapezium, and on the other side lying between the trapezium and the scaphoid. There has been a great deal of discussion concerning the occurrence of marginal structures in connection with the hand, held by some to represent additional digits, and designated in the hand the præpollex and the postminimus. Similar observations are made concerning the foot. The question is, whether or not we have evidence that the pentadactyle type of hand was derived from the heptadactyle type. The difficulty in determining the significance

1 Loc. cit., Vol. I, p. 596.

2 Loc. cit., p. 81.

3 Zuckerkandl. Discussion on Pfitzner's Paper, "Bemerkungen zum Aufbau des Menschlichen Carpus." Verhandlungen der Anatomischen Gesellschaft. Göttingen, 1893, p. 193.

4 Loc. cit. 1, p. 25.

5 Loc. cit. 2, p. 298.

6 Loc. cit., p. 13, (and Plate VI, Fig. 2).

of these marginal structures is increased, because we recognize a large number of supernumerary carpals occurring in different parts of the carpus. Thus the os centrale is a structure apparently always represented in the human embryo, but it soon blends with one of the neighbouring bones and loses thus its individuality. We find this bone in the Orang remaining separate throughout life. In my specimen it lay between the scaphoid, the trapezium and the os magnum. Vrolik[1] claims to have been the first to describe this bone in the carpus of the Orang. Later investigation has proved that in the human embryo a large number of carpal elements are often present. Thus Thilenius[2] in the human carpus in embryos, from the second to the fourth month, found such supernumerary bones, all appearing as hyaline cartilage, their structure differing in no manner from the normal eight carpals. Thilenius describes some thirteen of such. They unite with the neighbouring carpals or metacarpals, so that normally in man eight carpals finally result. The os centrale may join the scaphoid, the third metacarpal, the trapezoid, or the os magnum. Thilenius found the "prætrapezium" in four cases of 113 hands examined, whilst the os centrale was present in all cases without exception ; the other supernumerary carpals were present only occasionally. Pfitzner,[3] in a paper upon the human carpus, attempts to group all these supernumerary carpals in the human hand, and reconstructs the carpus so as to shew in a diagrammatic fashion the position occupied by all these additional carpal bones, and their relation to one another. It is in connection with the marginal bones, however, that the greatest interest has been aroused, and some anatomists look upon the bone described as the prætrapezium (or the os radiale externum) as representing a præpollex rudiment. Born[4] has examined similar structures in the tarsus of amphibians. In rana esculenta he figures a tarsus in which a supernumerary digit is added on the tibial side of the foot. This consisted of three catilaginous elements separated by joints and united with a tarsal element which it shared with the first metatarsal ; a somewhat similar condition was found in Bufo variabilis. Emery[5] traces various carpal elements in the larvæ of amphibia, and describes in the anura what he considers to represent the præpollex, and the præhallux ; he also demonstrated similar structures in rodents.

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1 Loc. cit., p. 13.

2 G. Thilenius, "Die 'Uberzähligen' Carpuselemente menschlicher Embryonen." Anatomischer Anzeiger. ix., 1894, p. 665.

3 Pfitzner, "Bermerkungen zum Aufbau des menschlichen Carpus." Verhandlungen der Anatomischen Gesellschaft. Göttingen, 1893, p. 186.

4 G. Born, "Die Sechste Zehe der Anuren." Morphologisches Jahrbuch, Vol. I, 1876, p. 436.

5 C. Emery, "Zur Morphologie des Hand und Fussskeletts." Anatomischer Anzeiger, 1890, p. 287.

Baur,[1] as the result of his investigations of the reptilian carpus, concluded that the præpollex element was one of the true carpals (radiale) displaced, being pressed out whilst the radiale centrale had taken its place and appeared as the representative of the true radiale. He considers that a similar view may be held regarding the amphibian carpus. Baur thus questions the validity of the præpollex theory. On the other hand, Bardeleben[2] is one of the strongest exponents of the theory. After studying the subject from the embryological standpoint and examining more than a thousand skeletons in the comparative anatomy collections of Berlin, Leyden, and London, he concludes that we must relinquish the old doctrine of five digits for the mammalia. The argument of Bardeleben is very interesting and ingenious. He finds in one of the Cape rodents (Pedetes capensis) in two skeletons a præpollex possessing a nail, and a postminimus in which were two bones. He also conducted his investigations among fossil forms and in the oldest fossil mammal in which the hand skeleton has been preserved he describes a præpollex rudiment. This fossil animal *Theriodesmus phylarchus*, comes also from South Africa (Nicholson[3]). The præpollex rudiment in the carpus of Theriodesmus has also been described by Thilenius.[4] The elements of the præpollex rudiment here, according to this authority, lie on the radial side of the hand, between the scaphoid, centrale and trapezium. Bardeleben, in his paper, attempts to trace the muscles of the præpollex and the post minimus, or rather their representatives, in the pentadactyle type. Thus the palmaris longus in the hand, and the plantaris in the foot, are looked upon as giving evidence of the existence of those supernumerary digits. Among lower animals (as has already been stated for the palmaris longus) these muscles give a varying number of tendons, numbering from three or four to seven, in some animals. Thus Bardeleben states that we have seven tendons representing the termination of the muscle in *Centetes* (one of the hedge-hog family of Madagascar). One of these tendons went to the præpollex and the other to the postminimus. Similar conditions were found in the plantaris. To the four groups of interossei present in the mammalian hand or foot Bardeleben would add the abductor muscles

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1 G. Baur, "Der Carpus der Schildkröten." Anatomischer Anzeiger, 1892, p. 206.

2 K. Bardeleben, "Ueber die Hand-und Fuss-Muskeln der Säugetiere, besonders die des Præpollex (Præhallux) und Postminimus," Anatomischer Anzeiger, 1890, p. 435.

3 A. Nicholson, "A Manual of Palæontology." Edin. and Lond., 1889. Vol. II, p. 1269. Nicholson's description of this mammal is as follows :—"In the Karoo system of South Africa, in a horizon which is probably of lower mesozoic age, has been obtained a slab showing the impression of a pectoral limb, apparently referable to a small mammal, which has been described under the name of *Theriodesmus*."

4 G. Thilenius, "Ueber Sesambeine fossiler Säugetiere," Anatomischer Anzeiger, 1894–95, p. 42.

of the first and last digits. The abductor pollicis, and the abductor hallucis, arising from what he considers to be the rudiments of the præpollex or præhallux, and the abductor minimi digiti in both hand and foot arising from the postminimus. These abductor muscles together with the so-called "interossei," Bardeleben would designate the "flexores breves profundi." In addition, Bardeleben claims certain of the marginal long muscles as contributing to the præpollex, etc.; among others, the extensor ossis metacarpi pollicis, and flexor carpi radialis acting on the præpollex, and the flexor carpi ulnaris acting on the post minimus rudiment. He traces similarly corresponding muscles in the foot. Fick[1] discovered in man what he believed to be a flexor præpollicis. It arose from the outer margin of the radius near the insertion of the pronator, and as a continuation of the flexor longus pollicis, a portion was inserted into the transverse carpal ligament, but the chief tendon of insertion was attached to the volar projections of the trapezium and the scaphoid, processes which were considered by Pfitzner to represent the prætrapezium, and therefore the præpollex rudiment. Fick places considerable importance upon the fact that this præpollex rudiment was still a "rudiment" in the oldest known mammal, and concludes that it is highly improbable, therefore, that the primitive mammal possessed a true præpollex. This fact would also go to disprove the other theory that the præpollex, etc., are secondary new formations. These digits, if they exist, do not appear to have made any progress in development in the mammal.

Gratiolet and Alix[2] found the extensor ossis metacarpi pollicis inserted in the Chimpanzee by two tendons—one into the trapezium and the other into the base of the first metacarpal. In a foot note these authors refer to the fact that no sesamoid bone was present in the slip to the trapezium, and its absence they attribute to the fact that the animal was young. The explanation is not valid, as the bone was present in my Orang, although it was a young specimen.

The *Abductor pollicis* (plate V, fig. *5 ab.p.*) muscle was well developed; it arose from the trapezium and the annular ligament, and was inserted into the radial border of the proximal phalanx of the thumb. The muscle would appear to present very few variations in the ape from the condition found in man. In Hepburn's Orang it arose from the annular ligament and had no direct attachment to the carpal bones.

The *Opponens pollicis* arose from the trapezium and the annular

1 Loc. cit. 1. p. 27.

2 Loc. cit., p. 163.

ligament, and from the tendon of the extensor ossis metacarpi pollicis, and was inserted into the radial border of the first metacarpal bone. Brooks[1] also described the origin from the extensor ossis metacarpi pollicis. The opponens is well developed in apes and resembles in attachment and development the same muscle in the human hand.

The *Adductor obliquus pollicis* arose from the bases of the second and third metacarpal bones and the ligaments over the anterior surface of the carpus. A portion of the adductor obliquus pollicis (indicated in plate V, fig. *5 a.ob.p.*) exists as a separate slip passing over the anterior surface of the metacarpal bone. This apparently corresponds to the muscle and tendon fasciculus which Langer[2] describes and figures, and which he believes to represent the flexor longus pollicis of man ; it is in consequence of the existence of this muscular slip that the Orang is capable of bending the terminal phalanx of the thumb.

The *Adductor transversus pollicis* arose from the base of the third metacarpal bone and the distal extremity of the second metacarpal bone, and from the fascia over the interossei muscles between the two bony points named. The adductor muscles of the thumb in the Orang thus correspond very closely to the muscles of the same group in the human hand.

The *Flexor brevis pollicis.* The inner head of the muscle (the " interosseus primus volaris" of Henle, plate V, fig. *5 f.b.p.2*) arose from the base of the first metacarpal bone, and was inserted into the base of the first phalanx with the adductor obliquus pollicis. The outer head of the flexor brevis pollicis (plate V, fig. *5 f.b.p. 1*), arose from the anterior annular ligament and was inserted into the radial portion of the base of the proximal phalanx. Flemming[3] looked upon the flexor brevis pollicis as a single headed muscle. This view has been proved to be incorrect by Cunningham[4] who holds that in the foot as in the hand the flexor brevis of the first digit is always a double headed muscle, and man is no exception to the rule. In man the ulnar head has suffered diminution and has been suppressed by the great development of the adductor. The inner head is the muscle which Henle called the "interosseus primus volaris." It was Bischoff who first enunciated the view that such was the case in demonstrating the true significance of the interosseus

1 Loc. cit., p. 82.

2 Loc. cit., p. 183.

3 W. Flemming, "Ueber den Flexor brevis pollicis und hallucis des Menschen." Anatomischer Anzeiger, 1887, pp. 68, 269.

4 D. J. Cunningham, "The flexor brevis pollicis and the flexor brevis hallucis in man," Anatomischer Anzeiger, 1892, p. 206.

primus volaris of Henle, and Cunningham confirms him in every particular. In the case of the foot Flemming advanced an argument based upon the nerve supply, but his argument fails, because Cunningham has shown that Flemming followed Henle and Schwalbe in describing the nerve supply of the fibular head to be from the external plantar nerve, whilst throughout the entire class of the mammalia Cunningham has only once found this head thus supplied (*i.e.*, in the fox-bat), with this exception it is always supplied by the internal plantar, as is the tibial head. Even if Flemming were right regarding the nerve supply Cunningham holds that the point would not afford sufficient proof, as it has been shown that where two nerves approach one another, a tendency to variation in the supply to muscles occurs when they reach the confines of their distribution. Cunningham states that in only one instance was he able to trace the nerve supply of the interosseus primus volaris in the hand, and in that instance it appeared to come from the deep branch of the ulnar.

The *Abductor minimi digiti* (plate V, fig. *5 ab.m.d.*), arose from the pisiform bone and the annular ligament, and was inserted into the base of the first phalanx of the little finger on its ulnar side.

The *Flexor brevis minimi digiti* (plate V, fig. *5 fl.b.m.d.*) arose from the unciform bone and the annular ligament, and was inserted into the base of the first phalanx of the fifth digit on its ulnar side. In Fick's Orang a second head arose from the palmaris longus tendon.

The *Opponens minimi digiti* (plate V, fig. *5 op.m.d.*) arose from the unciform bone and the annular ligament, and was inserted into the whole length of the metacarpal bone of the little finger.

The short muscles of the thenar and hypothenar eminences have a greater or less extension of their fibres of insertion beyond the bony points already described, and blend with the extensor aponeurosis on the dorsal aspect of the digits. In this respect they resemble the interossei, and Langer would, from this circumstance, argue in favour of the theory that these muscles are modified interossei.

The Orang would appear to have a greater development of thumb muscles than obtains in the hand of man as far as the development of those muscles which act upon the metacarpal bone is concerned, but the movements of the terminal phalanx are obviously very weak, the flexor longus pollicis being absent or extremely rudimentary. Further, it would appear that adduction to the index is the most powerful movement attainable, as judged from the development of the muscles. The

1 Loc. cit., p. 184.

flexor brevis pollicis is also well developed, probably better than in man, and thus flexion of the first phalanx can be well accomplished. The inner head of the flexor brevis resembles that in man in being very feebly developed, and in being completely pressed into the deeper parts and covered over by the adductor obliquus, and according to Bischoff[1] a similar condition is found in the Gibbon. In the Gorilla, Bischoff[2] was unable to separate the outer head of the flexor brevis from the opponens, or the inner head from the adductor obliquus. It would appear from reference to the records of various authorities, that whilst great variations exist among apes in the degree of development of the short muscles of the thumb, they are nevertheless all represented in the different species. Even in the spider monkey (Ateles) according to Huxley, in which the thumb is functionless, being wholly rudimentary and buried under the skin, all the muscles, abductors, adductors, short flexors and opponens are present, the long flexor alone of the muscles usually found in this situation being absent. A variation sometimes occurs according to Fick[3] and others, in the insertion of certain fibres of the adductor into the shaft of the metacarpal bone of the thumb, thus constituting a second opponens.

The *Interossei* (plate V, figs. 6 and 7). The first dorsal interosseous muscle arose from the ulnar side of the base of the first metacarpal by one head, whilst the other head arose from the dorsal, radial and palmar surfaces of the second metacarpal bone. The second dorsal interosseous arose from the ulnar half of the dorsal surface of the second metacarpal bone, and from the dorsal, radial and palmar aspects of the third metacarpal. The third dorsal interosseous arose from the radial half of the dorsal surface of the fourth metacarpal, and from the dorsal, ulnar and palmar aspects of the third metacarpal. The fourth dorsal interosseous arose from the radial half of the dorsal surface of the fifth metacarpal, and from the dorsal ulnar, and palmar aspects of the fourth metacarpal bone.

The palmar origins of the dorsal interossei, above described, were in all instances particularly well developed, forming in fact larger fasciculi than those arising from the dorsal region. On the palmar aspect of the third metacarpal bone the palmar origins of the second and third interossei meet together over the proximal half of the bone. The muscles were inserted as in man.

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1 Loc. cit. 1, p. 215.

2 Loc. cit. 2, p. 16.

3 Loc. cit. 2, p. 302.

The palmar interossei arose each by a single head from the metacarpal bone of the digit upon which it acts. The first palmar interosseous muscle arose from the palmar and ulnar surfaces of the second metacarpal, whilst the second and third palmar interossei arose from the palmar and radial surfaces of the fourth and fifth metacarpal bones respectively. They were inserted as in man.

The drawings (plate V) are faithful representations of the relations which existed, and one has reproduced in a diagrammatic fashion in fig. 4, plate IV, the relations of the interossei to the metacarpal bones as they appear in transverse section. The second, third and fourth metacarpal bones were thus completely surrounded by the interossei in the proximal two-thirds of their length.

Bischoff described[1] the interossei very fully in a large number of the lower apes and the anthropoid apes. He recognized the fact that there existed a palmar set of interossei as distinct and independent muscles. They vary in the number present in the different apes, but never exceed three, and were always developed in connection with the second, fourth and fifth digits. The double insertion of the various interossei, both palmar and dorsal, whereby they are on the one hand attached to the base of the proximal phalanx and on the other into the extensor aponeurotic expansion on the back of the phalanx, was first pointed out by Huxley[2] in anthropoid apes. The interossei and their attachments were fully described by Huxley in all four anthropoids. Bischoff found the interossei in the Gorilla developed as in man.[3]

The palmar portions of the dorsal interossei formed such very definite structures in my Orang that they attracted special attention. This segment of the dorsal interosseous muscle in fact resembles a palmar interosseous muscle, but this ventral segment is blended very intimately with the dorsal in the tendon of insertion of the muscle. The palmar interossei on the other hand remain independent structures throughout. This condition is very similar to that found in man, and, obviously, the description in most text books of human anatomy regarding these muscles is faulty. Gegenbaur,[4] however, describes and figures them in their correct relations. Hepburn[5] apparently found these ventral segments of the dorsal interossei, and, if I read his description aright, looked

1 Loc. cit. I, pp. 216, 224.

2 Loc. cit., Vol. I, p. 456.

3 Loc. cit. 2, p. 17.

4 C. Gegenbaur, "Lehrbuch der Anatomie des Menschen." Leipzig. Vol. I, p. 431. fig. 303.

5 Loc. cit., p. 174.

upon them as additional palmar interossei, and thus described six palmar interossei in the Chimpanzee instead of three. From one point of view Hepburn would appear to be justified in classing these ventral segments of the dorsal interossei with the palmar interossei, and this whole group of six muscles, as represented in my Orang, (plate V, figs. 6 and 7) might be referred to the intermediate layer of Cunningham which that author describes as constituting the " flexores breves." We shall return to the discussion of the interossei after describing the muscles of the foot.

In the dissection of the muscles of the lower extremity one found the fascia lata poorly developed, as compared with the similar structure in man.

The *Gracilis* arose from the body of the pubis by an origin 3.5 cm. wide, immediately external to the symphysis and corresponding in width of attachment to the depth of the symphysis. It did not extend to the descending ramus of the pubis ; it was inserted into the inner aspect of the tibia by an expanded aponeurosis of insertion 3 cm. wide. The upper limit of the insertion is 3 cm. below the articular surface of the tibia. It forms a flat ribbon-like muscle varying in width from 2 cm. near its origin to 1 cm. near its insertion, and was supplied by the obturator nerve. Fick remarks on the strong development of this muscle in the Orang, and also observed the absence of any origin from the pubic ramus.

The *Sartorius*, a very poorly developed muscle, arose from the ilium below the anterior superior spine, and was inserted into the inner surface of the tibia, above and anterior to the insertion of the gracilis. This muscle was only about one-fifth the size of the gracilis, and was supplied by the anterior crural nerve. On the right side Rudolf found that the muscle divided into two tendons of insertion, the anterior being inserted into the inner aspect of the tibia in the position indicated above for the left side, the posterior joined with the fascia around the knee joint. Between these two portions passed an artery of considerable size, which was found to arise from the femoral one inch above the knee, and run down the inner side of the leg to the cleft between the first and second toes, where it disappeared between the heads of the first dorsal interosseous muscle; a vein accompanied the artery and entered the femoral vein one inch above the knee. Fick[1] described an artery, the *arteria genus suprema*, in the Orang as a large vessel as thick as the profunda arising above the knee and extending with the saphenous nerve

1 Loc. cit. 1, p. 35.

to the dorsum of the foot. The sartorius muscle is usually very feebly developed in the anthropoid apes as compared with man. Gegenbaur states[1] that the sartorius is as well developed in the anthropoid apes as it is in man, but this is by no means invariably the case—in my Orang it was very rudimentary, and Fick found it so also in the same animal. Bischoff, too, and Duvernoy[2] state that the muscle is weak in the Gorilla, whilst Gratiolet and Alix[3] found it weakly developed in the Chimpanzee. The attachment of the sartorius to the inner side of the knee joint, similar to that found by Rudolf, has been described in man (Testut).

The *Adductor longus* arose from the inner portion of Poupart's ligament and from Gimbernat's ligament and from the pubis extending 1 cm. along the bone on the superior part of the horizontal ramus immediately external to the pubic spine; it was inserted into the inner aspect of the femur, the line of insertion being 1.5 cm. long, the lower limit of this line being only 2 cm. above the internal condyle.

The *Pectineus*, lying in the same plane as the adductor longus at its origin, arose from the horizontal ramus of the pubis, the origin being 1 cm. wide, continuous there with the adductor longus as it passes backwards and downwards, wrapping itself around the shaft of the femur, and was inserted into the posterior aspect of the femur at the junction of the middle and upper thirds, the insertion being 2.5 cm. wide.

The *Adductor brevis* arose from the pubis immediately beneath the adductor longus, by an origin 1.5 cm. wide; it was inserted into the posterior aspect of the femur on a plane posterior to that of the pectineus. The muscle was supplied by the obturator nerve.

The *Adductor magnus*, a large bulky muscle, arose from the pubic bone opposite the whole extent of the symphysis immediately subjacent to the gracilis, and on the same plane as the adductor brevis at its origin. The attachment of origin extends back along the descending ramus of the pubis and the ascending ramus of the ischium to within 1 cm. of the tuberosity of the ischium. The lower, or inner border was thick and rounded, whilst the upper (or outer) was thin and attenuated. The lower part of the muscle was inserted by a rounded tendon into the internal condyle of the femur, the lowest fibres passing to the internal lateral ligament of the knee joint. The muscle above this point is inserted into the posterior aspect of the femur in a plane posterior to the

1 Loc. cit., (Lehrbuch) Vol. I, p. 439.

2 Loc. cit., p. 90.

3 Loc. cit., p. 186.

adductor brevis, longus and pectineus, extending as high up on the shaft as the lower limit of the upper fifth of the bone. The muscle is supplied by the obturator nerve. The femoral vessels crossed over the anterior surface of the adductor longus near its insertion, and passed through the adductor magnus.

The *Adductores femoris* are, according to Bischoff, particularly strongly developed in all apes. In the Orang he was only able to distinguish the adductors longus and magnus; in all other apes investigated by him, including the Gorilla, Chimpanzee and Gibbon, he found the adductor group in five muscles, not only the pectineus, adductor magnus, longus and brevis, but an additional muscle arising from the crest of the pubis. This additional muscle from the crest Duvernoy[1] described in the Gorilla as a part of the pectineus.

The *floor of Scarpa's triangle.* From without inwards, the floor was formed by the iliacus, psoas, pectineus and adductor longus. The adductor brevis was entirely hidden from view, and there was a triangular interval between the psoas and pectineus (with the base uppermost), the floor of which was formed by the anterior ligaments of the hip joint covering the head of the femur. Passing down in the inner portion of the triangle was the femoral vein, lying in direct contact with the ramus of the pubis, and the anterior capsule of the hip joint and the femoral artery lying upon the inner edge of the psoas. The anterior crural nerve was separated from the femoral vessels by an interval of 2 cm. at the base of Scarpa's triangle, and lay upon the iliacus muscle.

The *Psoas* arose from the bodies of the lumbar vertebrae, and from the transverse processes. A well-developed *Psoas parvus* lay on the anterior aspect of the psoas. It arose from the body of the first lumbar vertebra and was inserted into the pubis. Hepburn found a psoas parvus in each of the four anthropoids. Fick also found it in the Orang and Bischoff in the Gorilla. The *Iliacus* arose from the concavity of the ilium. These two muscles (constituting the ilio-psoas) were inserted into the lesser trochanter of the femur. They lay in the same plane at the base of Scarpa's triangle, but afterwards the psoas came to lie in front of the iliacus and was inserted into the upper part of the lesser trochanter; the iliacus on the other hand, fully four times as wide as the psoas, was inserted into the lesser trochanter and into the shaft of the femur for 1 cm. below.

The *Rectus femoris* (Plate VI, fig. 8, rect.) arose by a single head from

1 Loc. cit., p. 85.

the anterior margin of the ilium at a point 3 cm. below the anterior superior spine, the width of origin being 2 cm., lying behind the iliacus and in front of the gluteus minimus; it passed into the thigh to join the quadriceps extensor muscle in the usual way. There was no reflected head of origin. Hepburn[1] found the double origin in the Orang, Chimpanzee and Gorilla, but not in the Gibbon. In establishing homologies between the muscles of the thigh and of the arm Humphrey[2] considered the rectus in the thigh to represent the scapular part of the triceps in the arm; and the shorter deeper portion, extending more laterally, formed by the vasti and crureus in the thigh, as representing the humeral head of the triceps in the arm.

The *Vastus externus* (Plate VI, fig. 8, v.i.) arose from the anterior inter-trochanteric line and from a line skirting the lower part of the great trochanter. Posteriorly a part arose from the trochanter itself. This part of the origin of the vastus externus embraces the insertion of the scansorius. Below this point the vastus externus arose from the postero-external aspect of the femur as low as the condyle, its origin here being immediately in front of the insertion of the gluteus maximus.

The *Vastus internus* arose from the antero-internal aspect of the femur as high as the root of the neck, its origin extending down to the internal condyle.

The *Crureus* arose from the anterior aspect of the femur as high as the neck, extending down between the lines of origin of the external and internal vasti as in man. These various muscles united as in man to form the *quadriceps extensor cruris.* This muscle is developed in apes as in man.

The *Gluteus maximus* (Plate VI., fig. 8, g. max.) arose from the posterior part of the iliac crest, the back of the sacrum, coccyx, and the sacrosciatic fascia by an origin 6 cm. wide, and was inserted, the lower (posterior) fibres, by a rounded cord which was traced down the external aspect of the femur to the external condyle, being intimately attached to the fascia lata throughout its whole extent. Most of the superficial fibres converged to this rounded tendon and have thus a fascial insertion, whilst the deep fibres were inserted into the femur by an attachment 1.5 cm. wide immediately external to the vastus externus, behind that muscle; the biceps lying posteriorly. The gluteus maximus was thus a very well developed muscle, and the proverbial

1 Loc. cit., p. 329.

2 Humphrey, "On the Disposition and Homologies of the Extensor and Flexor Muscles of the Leg and Forearm." Journ. of Anatomy and Physiology, Vol. III, 1869, p. 320.

diminutive size of the nates in apes, which is usually ascribed to the ill-developed glutei muscles, was not demonstrated in my specimen. Fick also[1] observed that the gluteus maximus, though relatively weak, was still a strong muscle in his Orang, its weight being 432 grms. whilst the gluteus maximus in a lean man was found by Langer to be 366 grms.

The *Gluteus medius* (Plate VI., fig. 8) was a large well developed muscle, which arose from the dorsal surface of the ilium as far forwards as the anterior superior spine, and backwards over the whole extent of the iliac crest, and from the dorsal surface of the ilium below this, some fibres coming from the posterior sacro-iliac ligament. Along its posterior border it is joined by the pyriformis muscle.

The *Pyriformis* is a narrow ribbon-like muscle arising from the anterior surface of the sacrum. It joins the gluteus medius on its deep aspect and proceeds to its insertion into the upper part of the great trochanter, as in man. It was intimately connected with the gluteus medius, but it was possible to separate them entirely from one another. It is customary, according to Bischoff, to find these two muscles closely connected in apes. Hepburn found them blended in all four anthropoids. The muscle is present in all apes.

The *Gluteus minimus* (Plate VI., fig. 8, g.min.) arose from the margin of the great sacro-sciatic foramen, and slightly from the dorsal surface of the ilium below this by an origin 2.5 cm. wide; it passed outwards beneath the pyriformis and the gluteus medius and was inserted into the anterior margin of the great trochanter.

The *Scansorius* (Plate VI., fig. 8, scan.) arose from the anterior margin of the ilium below the anterior superior spine by a broad base of origin 3.5 cm. wide, the muscle being triangular in shape. It was inserted by its apex into the anterior border of the great trochanter by an insertion 1.5 cm. wide immediately in front of the gluteus medius and is embraced at its insertion by the vastus externus. This well-developed muscle lay at its origin between the gluteus medius behind and the iliacus in front. The narrow ill-developed sartorius separates the iliacus from the scansorius, whilst the rectus also separates these two muscles along the inner border of the scansorius. The muscle was very distinct and separate from both the gluteus medius and the gluteus minimus.

The scansorius is described by Fick as a typical Orang muscle. It is certainly best developed as a separate muscle in the Orang, whilst in the other apes (both anthropoid and lower apes) it is more or less

1 Loc. cit. 1, p. 36.

blended with other muscles. Fick[1] described it as a muscle wholly separate and distinct in his first Orang, whilst in the second Orang dissected by him[2] the muscle was superficially united with the gluteus medius. Bischoff[3] also describes the scansorius in the Orang as a separate muscle, and so too do Huxley,[4] Owen,[5] Hepburn,[6] and Langer,[7] whilst Chapman[8] figures the muscle, but looks upon it as a portion of the gluteus minimus. Gratiolet and Alix[9] in their description of the Chimpanzee describe the gluteus medius and the gluteus minimus together as forming a single muscular mass, and the anterior portion of the muscle sheet thus described would correspond to the scansorius, although not so designated by them, and certainly not existing as a muscle completely separate in their specimen. Hepburn[6] however describes it as a separate muscle in the Chimpanzee, as do also Huxley[10] and Owen,[5] whilst Bischoff[3] and Champneys[11] describe it in the Chimpanzee as closely connected with the gluteus minimus. Macalister[12] found it attached to the gluteus medius in one Chimpanzee and to the minimus in another. In the other anthropoids, namely the Gibbon and the Gorilla, it has not been described as a separate muscle save in the fœtal Gibbon where Deniker[13] found it well marked, whilst in the fœtal Gorilla it was not completely separated from the gluteus minimus. Bischoff[14] and Hepburn[15] both found it united with the gluteus minimus in the Gibbon, whilst Huxley[16] states that it is not very distinctly represented in that animal. In the Gorilla it has not been described as a separate muscle. Duvernoy in his description of this region in the Gorilla[17] makes no mention of the scansorius, Bischoff[18] says it fails in the Gorilla, but the gluteus minimus arises

1 Loc. cit., p. 36.
2 Loc. cit. 2, p. 303.
3 Loc. cit. 1, p. 224.
4 Loc. cit., Vol. I, p. 596.
5 Loc. cit., p. 68.
6 Loc. cit., p. 325.
7 Loc. cit., p. 186.
8 Loc. cit., p. 163.
9 Loc. cit., p. 179.
10 Loc. cit., Vol. I, p. 428.
11 Loc. cit., p. 193.
12 Loc. cit., p. 504.
13 Loc. cit., p. 168.
14 Loc. cit. 1, p. 224.
15 Loc. cit., p. 325.
16 Loc. cit., Vol. I, p. 647.
17 Loc. cit., pp. 84, 85.
18 Loc. cit. 2, p. 19.

from the anterior iliac margin, and similarly Hepburn[1] describes it as blended with the gluteus minimus. On the other hand Macalister[2] describes it as uniting with the gluteus medius (not minimus) in the Gorilla. Concerning the occurrence of the muscle among the lower apes, Huxley[3] tells us that in Cynopithecinæ the scansorius is found, but that it is sometimes blended with the gluteus minimus. Bischoff,[4] whilst he states that it fails in the lower apes generally, mentions that it is represented by a weak bundle in Cynocephalus, Cercopithecus and Macacus.

Thus we find that the scansorius is best developed as a separate muscle in the Orang and the Chimpanzee among anthropoid apes, and in all other apes it varies very considerably in its development, and is usually blended with the gluteus minimus or the gluteus medius, commonly the former.

The scansorius would thus appear to have more or less intimate connection with the gluteus medius and minimus. Fick combats the suggestion of Henke that it is developed from the iliacus, on the ground that the sartorius muscle intervenes between these two muscles ; in my specimen I not only found the sartorius intervening but also the rectus. Bischoff, too, refers to the rectus intervening between the ilio-psoas, and what he believes to be the representative of the scansorius in the Gibbon.

The function of the scansorius muscle was demonstrated by Owen,[5] who called it the " Invertor femoris," holding that it was a powerful rotator of the thigh and could have very little effect in drawing the thigh up. He states regarding the muscle " that it appears rather to have reference to that structure in the hip joint which, in the Orang especially, from the absence of the ligamentum teres, and in the Chimpanzee, from the yielding texture of that ligament, permits a greater extent of inward rotation than can be accomplished in man." Fick[6] questions the appropriateness of calling this muscle the climbing muscle. Flexion of the femur which is carried out to a limited extent by the scansorius, is a movement performed in climbing, but there are many other more powerful flexors of the femur. Then the scansorius rotates the thigh inwards in a forcible manner, and this is apparently its chief action. The ape, however, does not appear to rotate the thigh inwards in

1 Loc. cit., p. 325.

2 Loc. cit., p. 504.

3 Loc. cit., Vol. II, p. 40.

4 Loc. cit. 1, p. 224.

5 Loc. cit., p. 68.

6 Loc. cit. 1, p. 36.

climbing. If it did so it would necessarily throw the leg and foot outwards at the same time, in consequence of the fact that the knee is flexed and never straight in the Orang ; as a matter of fact, in climbing upwards the ape applies the sole of the foot to the tree, whilst the thigh is abducted and rotated out. The ape thus climbs in a different fashion from that in which a boy would climb a pole, with thighs adducted and rotated in and with the knees hard pressed inwards. Fick states, however, that man in climbing with naked feet, as for example, the child of a Malay negro, will climb as the ape does, with the soles of the feet applied to the trunk of the tree and with thighs rotated out. This action of flexion of the femur with rotation outwards is not the function of the scansorius but of the ilio-psoas. In this sense, therefore, the name scansorius is inapplicable. Fick admits that the scansorius may be brought into action when the ape is climbing from one branch to another, when, he observes, the animal very frequently performs this movement with flexed thigh rotated inwards.

The scansorius muscle was first described and named by Traill (quoted by Bischoff, from Memoirs of the Wernerian Nat. His. Soc., Vol. III., p. 29, 1821) in the Chimpanzee. According to Testut[1] there is frequently found in man a small fasciculus more or less differentiated from the gluteus minimus anteriorly, which passes to be inserted into the great trochanter ; this Testut considers the representative of the scansorius in man. This fasciculus, he adds, exists normally in a large number of mammals.

The weak development of the glutei muscles in general in man is to be ascribed to the erect attitude, whilst again the comparatively strong development of that part of the gluteus maximus in the ape which proceeds down the thigh—in my Orang as far as the external condyle—is associated with climbing, the thigh being carried back with considerable force by that part of the muscle.

The *Tensor fasciæ femoris* was entirely absent in my Orang. Bischoff states regarding it that the fascia lata is more weakly developed than in man, and the muscle is scarcely present as an independent muscle in any instance, but may be represented by a few fibres derived from the anterior part of the gluteus maximus. This agrees with the freer and more isolated action of the thigh muscles in apes, as is necessary in climbing, whilst in man these muscles are required to be more firmly bound together in the erect position and in walking.

1 Loc. cit., Vol. I, pt. 2, p. 837.

The *Obturator internus* arose as in man, and passed over the lesser sciatic notch, where it is joined by a well-developed *Gemellus inferior* and a less strongly developed *Gemellus superior.* The muscle was inserted into the upper part of the great trochanter behind the insertion of the pyriformis and in contact with the capsule of the hip joint. Fick likewise describes the superior gemellus as weak in the Orang, whilst Hepburn found them both well developed. Bischoff in the Gorilla found the obturator internus completely blended with the quadratus femoris.

The *Obturator externus* arose as in man and, appearing between the obturator internus and quadratus femoris, it found insertion into the inner part of the great trochanter just behind the obturator internus.

The *Quadratus femoris* was a well-developed muscle. It arose from the outer part of the ischial tuberosity by an origin 1.5 cm. wide and was inserted into the posterior part of the great trochanter and the shaft of the femur below this process. Langer[1] found the muscle closely connected with, and hardly separable from, the adductor magnus, and he therefore looked upon it as one of the adductor group. The muscle is sometimes blended with the great adductor in man.

The *Semitendinosus* arose from the tuberosity of the ischium and the bone immediately in front of this by an origin 1 cm. wide, and was inserted into the tibia, the tendon expanding to have a wide attachment (2 cm.) into the antero-internal surface of the tibia behind the insertion of the gracilis. Rudolf on the right side found a second head of origin coming from the ischial ramus and joining the muscle 1½ inches from its insertion.

The *Biceps* arose from the outer part of the tuberosity of the ischium, immediately posterior to and slightly in front of the semitendinosus. The two were closely associated at their origin. The muscle was inserted along the whole length of the lower two-thirds of the shaft of the femur, immediately behind the origin of the vastus externus, also into the external lateral ligament of the knee joint, the external tuberosity of the tibia, the head of the fibula and into the fascia on the outer surface of the upper part of the leg. Associated with this muscle is another (the femoral head of the Biceps in man) which arose from the shaft of the femur immediately behind (*i.e.*, internal to) the line of the femoral insertion of the biceps as described above. The line of origin was 4.5 cm. wide. The muscle passed to be inserted into the fascia of

1 Loc. cit., p. 187.

the leg extending downwards from the level of the knee joint; the fascia over the muscles of the leg being here very strongly developed. Fick[1] describes the ischio-femoral portion of the biceps as the direct antagonist of the scansorius, the action of the former muscle being to extend the hip and to rotate it outwards; both these muscles are absent in man. Langer[2] describes the long head of the biceps as in part going to be inserted into the patella, and he characterizes it as the great "sprungmuskel" which, in quadrupeds, is capable of extending all three joints, hip, knee and ankle. In Langer's Orang connection with the tendo Achillis alone was absent. The ischio-femoralis is sometimes joined with the gluteus maximus in the Orang, but more frequently is completely separate. In the Gorilla, Bischoff[3] describes the two heads of the biceps, but states that the long head is not inserted into the linea aspera as in the Orang, but passes to the head of the fibula and the fascia cruris. In the Chimpanzee and the Gibbon, according to the same authority, the Biceps is most human-like but extends also into the fascia cruris. In the lower apes the biceps has only one head—the long head—which is inserted, not into the fibula, but into the tibia; this fact is noted by Bischoff and by Huxley.[4] Hepburn found both heads present in the Orang, and, whilst one was inserted into the fibula and the other into the tibia, there was no femoral attachment. The biceps has been found in rare cases inserted in part into the tendo Achillis in man (Testut).

The *Semimembranosus* arose external to the point of attachment of the semitendinosus from the posterior part of the tuberosity of the ischium and the bone immediately in front of this (0.75 cm. wide); it was inserted into the inner aspect of the head of the tibia.

The absence of a ligamentum teres in the hip joint was noted. No vestige of this structure could be found; the head of the femur presenting an unbroken surface smooth throughout. One could not determine any definite ilio-femoral ligament, although the capsule of the hip-joint was thickened anteriorly in the line of its usual development.

The shortness of the hamstring muscles in the Orang and their low attachment, removed some distance below the knee, prevent complete extension of the leg at that joint, and this inability to extend at the knee is necessarily still further increased when the hip-joint is flexed.

1 Loc. cit. 1, p. 39.
2 Loc. cit., p. 187.
3 Loc. cit. 2, p. 21.
4 Loc. cit. Vol. II, p. 40.

A strong fascia covered the muscles of the calf. The anterior annular ligament of the ankle-joint was a well-developed structure consisting of two distinct bands, the upper passing from the internal malleolus outwards to be attached to the lower part of the fibula; the lower having a broad attachment to the external malleolus, becomes somewhat narrowed as it is attached to the fascia on the inner side of the foot below the internal malleolus. The external annular ligament too was well developed as it passed over the peronei muscles, as was also the internal annular ligament over the structures at the inner ankle.

The *Tibialis anticus* arose from the anterior aspect of the upper half of the tibia, from the external tuberosity and the interosseous membrane, and from the fascia over the muscle. The muscle became tendinous immediately above the ankle, where two tendons are readily distinguishable. The smaller one, which arose from the fleshy fasciculi of the anterior and outer part of the muscle, was inserted into the base of the first metatarsal bone at the junction of the inner and plantar surfaces. The larger tendon (three times the size of the former) was inserted into the internal cuneiform bone. The slip inserted into the first metatarsal bone acts as a strong abductor of the great toe, as does also the extensor longus hallucis.

The tibialis anticus in certain of the anthropoid apes is more or less completely divided into two muscles. In man we have a single muscle, and a single tendon which, however, divides at its extremity to be inserted into the internal cuneiform and the first metatarsal bone. This double insertion in man is an indication of the complete separation into two portions occurring in some apes. In the Orang and Chimpanzee Bischoff[1] found this division complete, and, in fact, in the Chimpanzee he found a third tibialis anticus arising in common with the extensor longus digitorum, but completely separated from it, and dividing into two tendons at the ankle to be inserted into the inner margin of the foot. In the Gibbon, Bischoff found a single muscle with a single tendon passing to the internal cuneiform bone. Huxley,[2] however, found a double insertion of the muscle in that animal. In the Gorilla, Bischoff[3] and Duvernoy[4] describe the muscle as in man, its tendon dividing for insertion into the first metatarsal and the internal cuneiform. In all other apes, Bischoff asserts, the tibialis anticus is double. It would appear, therefore, that in all apes the double insertion is almost

1 Loc. cit. 1, p. 227.

2 Loc. cit., Vol. I, p. 648.

3 Loc. cit. 2, p. 21.

4 Loc. cit., p. 94.

invariable ; in this respect it may be compared to the extensor ossis metacarpi pollicis in the hand.

The *Extensor longus hallucis* arose from the upper fifth of the fibula and from the interosseous membrane, the line of origin being very short, and was inserted into the great toe, with similar relations to those in man. Fick[1] observed in an Orang a tendon given by this muscle to the second toe. Bischoff states that in all apes this muscle resembles that of man, but, except in the Gibbon, it does not extend along the dorsum of the foot as in man, but goes with the tibialis anticus to the inner side (the latter muscle being attached to the internal cuneiform), and runs along the inner margin of the foot to the first phalanx. The muscle must in its direction act on the great toe as an abductor as well as an extensor. In the Gibbon alone the tendon runs a course similar to that in man.

The *Extensor longus digitorum* arose from the internal tuberosity of the tibia and the intermuscular septum, also from the head of the fibula and the interosseous membrane, the origin being only 1.5 cm. wide. It was inserted into the four outer toes.

Extensor brevis digitorum arose from the outer and superior surfaces of the os calcis. It was closely associated at its origin on the outer side of the foot with the insertion of the peroneus brevis. It was inserted into the four inner toes, having a similar relationship to the extensor longus digitorum as in man ; that for the great toe formed a separate and distinct muscle, running almost at right angles to the main part of the muscle, and passed to the great toe with the extensor longus hallucis. Duvernoy[2] describes this slip in the Gorillà as a separate muscle of the great toe. Langer[3] describes in the foot a similar interdigital membrane to that found in the hand, the toes being thus even more sunken in the foot than are the fingers in the hand.

The *Peroneus tertius* was absent, as is the case apparently with all apes, both the anthropoids and the lower apes. This muscle is peculiar to man among mammals, and there is some evidence that its development has to do with the erect attitude assumed by man. Ramsay Smith[4] believes that it serves an important function in preventing spasmodic extension of the ankle joint in ordinary walking. This, according to Smith, occurred in cases where the muscle was paralysed.

1 Loc. cit. 2, p. 303.

2 Loc. cit., p. 103.

3 Loc. cit., p. 190.

4 W. Ramsay Smith, "The Functions of the Peroneus Tertius Muscle." Edinburgh Medical Journal, 1882, p. 632.

The *Peroneus longus* arose from the head of the fibula on its outer aspect, and from the intermuscular septum, the line of origin being 2 cm. long. The musculo-cutaneous nerve passed between the upper part of the muscle and the fibula; the muscle became tendinous at the junction of the lower and middle thirds of the leg; the tendon grooved the cuboid bone, and passing inwards across the sole of the foot, it was inserted into the base of the first metatarsal bone at the junction of the plantar and outer margins. The peroneus longus had also a very definite slip of insertion into the fifth metatarsal bone. Fick[1] also describes this double insertion in the Orang.

The *Peroneus brevis* arose over 4.5 cm. of the outer side of the fibula, along an oblique line extending from above and in front, downwards and backwards to the posterior aspect of the bone immediately above the external malleolus. The upper limit of its origin was as high as the junction of the upper and the middle thirds of the bone. It was inserted into the base of the fifth metatarsal bone, and into a tendinous arch extending from the os calcis to the base of the fifth metatarsal bone ("abductor ossis metatarsi quinti" of Huxley). This extensive and strong insertion band of the muscle gives rise to certain fibres of the abductor minimi digiti. Some of the tendon fibres of the peroneus brevis were directly continuous with the peroneus longus tendon in the sole.

Bischoff,[2] in comparing the peroneus longus in man and apes, refers to the fact that on account of the saddle shape of the joint between the cuneiform and the first metatarsal, and of the more isolated position of the great toe in the ape as compared with man, the peroneus longus in the ape acts in bringing the great toe into opposition with the other toes, whilst in man it acts on the anterior part of the foot as a whole.

Bischoff describes another muscle in the ape, the *Peroneus parvus*.[3] This muscle, he says in lower apes exists as a fourth peroneus. It lies between the longus and brevis arising from the fibula. It becomes tendinous in the leg, and extending to the outer margin of the foot passes to the first phalanx of the little toe, where it unites with the tendon of the flexor digitorum communis longus. This muscle, Bischoff states, evidently corresponds with the well-known tendon which almost always in man goes from the tendon of the peroneus brevis and

1 Loc. cit. 1, p. 42.
2 Loc. cit. 1, p. 229.
3 Loc. cit. 1, p. 230.

joins the extensor tendon of the little toe, derived from the extensor digitorum communis longus. Huxley[1] describes this muscle in the lower apes ; he calls it the *Peroneus quinti digiti.* The muscle appears to be very uncommon in the anthropoid apes, although Bischoff thought that possibly a tendon coursing along the outer margin of the foot, which proceeds from the tendon of the peroneus brevis and is inserted with the extensor tendon of the little toe, might be looked upon as a rudiment of the peroneus parvus in the Gorilla. He found this tendon also in the Chimpanzee, as also did Gratiolet and Alix.[2] This tendon has apparently not been found in the Orang, but Huxley[3] describes in the Chimpanzee a muscular slip arising from the calcaneum apparently detached from the abductor minimi digiti, and ending in a tendon inserted into the base of the fifth metatarsal bone. This, Huxley suggests, might be called the "*abductor ossis metatarsi quinti.*" This corresponds precisely to the tendinous arch which I describe in the Orang in connection with the insertion of the peroneus brevis, and possibly represents a rudiment of the peroneus parvus.

Fick[4] has described a peroneous parvus in the Orang. Hitherto it was held that it did not exist in anthropoids, and apparently it is of rare occurrence among those apes, as this is the only instance in which I find its presence noted, although carefully sought for by various observers.

Ruge[5] makes some interesting observations on the peroneal group of muscles. He considers that the peroneus longus tendon in the mammalia wanders from the anterior to the lateral part of the limb. Thus in carnivora it originally lies on the anterior surface of the fibula, in rodents the tendon at one time lies upon the lateral aspect of the external malleolus and at another time behind it. In the ape the tendon lies in a special synovial sheath separated from the brevis, whilst in man they lie both together in the same synovial sheath. Ruge evidently considers the extensor brevis digitorum to be derived from the peroneal group, and represents it as wandering toward the dorsum of the foot, as would appear by studying its relation in different mammals. In marsupials, only two bellies pass over for insertion into the first and second toes. In rodents and insectivora three bellies exist for the first, second and third toes; and in carnivora, apes, and man, there

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1 Loc. cit., Vol. II, pp. 40, 94, 124.

2 Loc. cit., p. 198.

3 Loc. cit., Vol. I, p. 429.

4 Loc. cit. 1, p. 42.

5 Dr. George Ruge, "Untersuchung über die Extensorengruppe am Unterschenkel und Fusse der Säugethiere." Morphologisches Jahrbuch, Vol. IV, 1878, p. 592.

are muscle bellies for four toes, viz.: the first, second, third and fourth, whilst that for the fifth toe still retains its original position among the peronei.

The *Gastrocnemius.* The outer head arose from the posterior aspect of the external condyle, and by a few fibres from the posterior ligament of the knee joint. The fibres of origin were closely associated with the flexor digitorum fibularis, the latter having a femoral origin behind the external condyle immediately internal to and above the place of attachment of the gastrocnemius. The inner head arose from the femur immediately above the internal condyle and from the posterior ligament of the knee joint. Langer and Fick both observed the connection of the outer head with the flexor digitorum fibularis. The muscle is not nearly so well developed as in man.

The *Soleus* arose by a narrow attachment (1 cm. wide) from the posterior part of the head of fibula ; this was joined by a delicate, thread-like, distinctly tendinous structure which descends from the outer and posterior surface of the tibia. Macalister[1] found a trace of a tibial head in the Chimpanzee, but all other observers (Huxley, Fick, Langer, Bischoff, etc.,) state that the tibial head of the soleus is absent in all apes. The soleus and gastrocnemius unite in a tendo Achillis which is wholly tendinous at a point 3 cm. above the heel. In Fick's[2] Orang the fleshy fibres of the muscle extended down to its insertion into the os calcis, and this condition is held by him to be characteristic of anthropoids as compared with that found in the lower apes and in man. Bischoff agrees with this statement excepting in the case of the Gibbon, in which the tendo Achillis, according to him, is developed as in man.

The *Popliteus* arose from the outer condyle of the femur within the knee joint passing through the posterior ligament of the knee. The muscle was overlaid at its origin by the outer head of the gastrocnemius and the femoral head of the flexor longus hallucis. It was crossed about its middle by the inner head of the gastrocnemius. Rudolf found on the right side that its nerve entered the superficial surface. It was inserted into the posterior surface of the tibia in its upper fifth and along the inner border of that bone extending down from the internal tibial condyle for one-fourth of the length of the bone. Langer and Fick both describe sesamoid bones in connection with the tendons of origin of the popliteus in the Orang. Humphrey[4] looks upon the popliteus

1 Loc. cit., p. 205.

2 Loc. cit. 1, p. 40.

3 Loc. cit. 1, p. 228.

4 Loc. cit., p. 328.

in the leg as the homologue of the pronator radii teres in the forearm. The occasional second head of origin of the muscle from the fibula in man may correspond to the ulnar origin of the pronator. Bischoff[1] admits that pronation is possible to some degree in the knee of the ape, whilst in man of course the popliteus acts only as a flexor. Melzer[2] considers the homologies to be as follows :

Supinator longus .... } Pronator teres (humeral head) }	.... Gastrocnemius	{ inner head. { outer head.
Pronator teres (ulnar head).	..... Popliteus.	

Macalister[3] looks upon the inner head of the gastrocnemius as the homologue of the pronator radii teres. It is superficial and not deep like the popliteus, and this fact he considers to be in favour of his hypothesis.

The *Plantaris* was absent and it would appear that the muscle is very rarely present in anthropoid apes. The only instance in which it was found in the Orang was in that dissected by Sandifort, who is stated by Fick[4] to have found it in that animal. It is frequently absent in man. Whilst the plantaris is almost invariably absent in anthropoid apes, it is well-developed, according to Bischoff,[5] in the lower apes (Cynocephalus, Cercopithecus, Macacus and Pithecia), forming a strong tendon passing under the posterior part of the os calcis, and it may be followed into the sole where it joins the plantar fascia. Bischoff,[6] however, found a slightly developed plantaris arise on both sides in the Chimpanzee, and in this animal, too, it has been described by Macalister[7] as present on the right side in one Chimpanzee and absent on both sides in another Chimpanzee. It is, however, frequently absent in this animal, and with the exception of the one instance recorded by Sandifort in the Orang, it has not been found in any of the other anthropoid apes, although carefully sought for, and its absence recorded by various authors. The plantaris in the leg doubtless corresponds to the palmaris longus in the forearm and has the same relation to the plantar fascia that the latter muscle has to the palmar fascia (see page 33). Thus Sutton[8] holds that the plantar fascia is derived from the degeneration of the distal end of

1 Loc. cit. 2, p. 23.

2 W. Melzer, "Zur Homologie der menschlichen Extremitäten." Internationale Monatsschrift fü Anatomie und Physiologie, Vol. XI, 1894, p. 209.

3 A. Macalister, "On the Arrangement of the Pronator Muscles in the Limbs of Vertebrate Animals." Journ. of Anat. and Phys., Vol. III, 1869, p. 340.

4 Loc. cit. 1, p. 41.

5 Loc. cit. 1, p. 229.

6 Loc. cit. 2, p. 22.

7 Loc. cit., p. 505.

8 Loc. cit., p. 16.

the plantaris muscle. We find the muscle in a more fully developed condition in the lower mammalia. Cunningham[1] described it in the marsupials. In Thylacinus this muscle arises in common with the outer head of the gastrocnemius and remains fused with its under surface for a considerable distance. It ends in a strong tendon which proceeds downwards along the inner side of the tendo Achillis to the heel, where it expands and, passing superficially to the tendo Achillis, enters the sole. Here it spreads out in the form of a plantar fascia which divides into three slips for the index, medius and annularis. The plantar fascia is not attached to the subjacent muscles, and each of its terminal slips bifurcates to embrace the metatarso-phalangeal joint and is attached to the ligamentous structures around that articulation. Sutton describes a somewhat similar arrangement in the Armadillo. In higher mammalia it would appear that, owing to the backward growth of the os calcis the plantaris is shut off from its direct connection with the plantar fascia, and terminates by being inserted into the os calcis itself.

The *Flexor digitorum fibularis* (the flexor longus hallucis of human anatomy), was a very large bulky muscle of extensive origin from the posterior aspect of the external femoral condyle where it embraced the origin of the outer head of the gastrocnemius, also from the posterior and external lateral ligaments of the knee joint, the posterior aspect of the fibula as low as the junction between the middle and lower thirds, also from the fascia between it and the peronei muscles.

The *Flexor digitorum tibialis* (the flexor longus digitorum of human anatomy), was also a very bulky muscle and arose from the posterior aspect of the tibia immediately external to the attachment of the popliteus muscle as high up as the head of the tibia ; it was attached along a line running downwards and inwards to the inner margin of the tibia at the junction of its upper and middle thirds. This portion of the muscle is joined by a well developed band of fibres descending from the fascia over the lower part of the popliteus muscle. These fibres may be traced upwards, and are found attached to the inner tuberosity of the tibia. Another very distinct head of origin of this muscle arose from the fascia over the tibialis posticus muscle, and extended as far as the inner margin of the fibula.

The two muscles just described, viz., the flexor digitorum fibularis

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1 D. J. Cunningham, "Report on the Marsupialia, with an Account of the Comparative Anatomy of the intrinsic Muscles and Nerves of the Mammalian Pes." Report of the Voyage of H. M. S. "Challenger," Vol. V, 1882, Part XVI, p. 41.

and the flexor digitorum tibialis, both became tendinous immediately above the inner ankle, and proceeded towards the sole of the foot. They passed behind the inner ankle, where they lay in separate osteo-fibrous canals, separated from one another by a well-defined fibrous partition, the nerves and vessels which pass into the sole lying on a more superficial plane immediately over the fibrous septum between the muscles. The flexor digitorum fibularis was confined in a groove in the posterior part of the astragalus and passed immediately subjacent to and in contact with the sustentaculum tali of the os calcis, the flexor digitorum tibialis occupying a position anterior to this. In the sole of the foot the two muscles crossed one another, the tendon of the flexor longus tibialis occupying the more superficial position. From the flexor longus tibialis a considerable contribution was given to the flexor brevis digitorum to be presently described, and from the same source the deep flexor tendons were supplied for the second and fifth toes, whilst the deep flexor tendons for the third and fourth digits passed from the flexor digitorum fibularis. Four *lumbricales* existed in connection with these deep flexors. The first lumbrical was attached solely to the tibial side of the tendon of the flexor digitorum tibialis for the second toe. The second and third lumbricals were connected with the tibial side of the tendon of the flexor digitorum fibularis for the third aud fourth toes. The fourth lumbrical arose by two heads, one from the tibial side of the flexor digitorum tibialis of the fifth toe, and the other head from the fibular side of the tendon of the flexor digitorum fibularis of the fourth toe.

The *Flexor brevis digitorum* was closely associated in the sole with the tibial and fibular flexors. It was a well-developed muscle, and arose from the inferior and inner aspects of the os calcis by an origin 2 cm. wide. It was inserted into the four outer toes. The tendon for the third toe was the strongest, and received the bulk of the fleshy fibres of the muscle. This tendon split into two portions, which passed to be inserted into the ventral aspect of the middle phalanx at its base, allowing the tendon of the flexor digitorum fibularis to perforate and pass beneath in the usual fashion. The division to the second toe was similar in its relations, but was not as strongly developed. The division for the fourth toe was very delicate, its tendon being very fine and thread-like. This delicate tendon was joined by a well-developed tendon, which was derived from a bundle of fleshy fibres in the sole, having their origin from the flexor digitorum tibialis opposite the inner ankle. The tendon for the fourth toe, being so constituted by fibres derived from the two muscles named, passed on and split to allow the perforating tendon (flexor digitorum fibularis) to pass beneath, and had similar attachments in the fourth toe to those described for the short flexor in the third toe. The tendinous slip for the fifth toe was extremely delicate, and was joined by a slip (which seemed to be wholly tendinous) from the flexor digitorum tibialis of similar character and connections as that described for the fourth toe. It will be observed that the flexor digitorum fibularis gave no tendon for the hallux.

It would appear that the distribution of the flexor digitorum fibularis to the third and fourth toes is very constant, occurring, according to Bischoff, in all apes,[1] and further in all apes save the Orang, according to the same authority, a tendon is given by this muscle to the great toe, but this tendon is extremely weak, excepting in the Gorilla, where Bischoff states that a very strong tendon to the hallux is found.[2] Duvernoy[3] describes and figures the flexor longus hallucis in the Gorilla as giving a very powerful tendon to the great toe, and also supplying the third and fourth toes. The tendon to the hallux fails utterly in the Orang. In Huxley's Gibbon,[4] the flexor digitorum fibularis was distributed to the first, second, third and fourth digits, and the flexor digitorum tibialis was supplied to the fifth digit only.

There can be no doubt that the flexor longus fibularis represents the flexor longus hallucis in man, and the flexor longus tibialis the flexor longus digitorum in man. Dobson[5] has traced the homologies of the long flexor muscles of the foot throughout the mammalia. In the human subject Turner[6] has shown that there is frequent communication in man of the flexor longus hallucis with the flexor tendons of the four outer toes. Thus, in fifty specimens dissected, he found that in eleven cases such a communication existed with the second toe only; in twenty cases, with the second and third toes, and in eighteen, with the second, third and fourth toes, whilst, in one specimen, there was a communication with the four outer toes. Schulze[7] gives somewhat similar results, but has not observed a communication with the fifth toe.

Huxley[8] observed a contribution to the flexor brevis digitorum from the flexor digitorum tibialis in the Gorilla, and in the Orang he also

1 Loc. cit. 1, p. 232.

2 Loc. cit. 2, p. 30.

3 Loc. cit. p. 112.

4 Loc. cit., Vol. I, p. 648.

5 G. E. Dobson, "On the Homologies of the Long Flexor Muscles of the Feet of Mammalia, with Remarks on the Value of their Leading Modifications in Classification." Journ. of Anat. and Phys., Vol. XVII, 1883, p. 142.

6 Loc. cit., p. 181.

7 Loc. cit., p. 1.

8 Loc. cit., Vol. I, pp. 538, 596.

noted a contribution similar to that I have described above in my Orang. He observed a remarkable deviation from the human type in Cynopithecinæ where the flexor brevis pedis arose partly from the tendon of the plantaris (where this passes over the pulley-like hinder extremity of the calcaneum, to end in the plantar fascia) and partly from the long flexor tendons, so that it completely lost its connection with the os calcis.[1] Again, Turner[2] observed in man that the tendon of the short flexor for the little toe in one case arose from the common flexor tendon previous to the sub-division of that structure. Similar communications between the short and long flexors have been recorded in the apes by Bischoff.[3] Regarding variations in origin in man it may be noted that the flexor brevis sometimes arises from the cuboid bone, the cuneiform bones, or the bases of the metatarsal bones (Testut).

The *Flexor accessorius* (The "*Caro quadrata*" of Sylvius). On the left side of my Orang there was not a vestige of this muscle, whilst on the right side Rudolf found a very thin muscle possessing two heads of origin from the os calcis, and inserted into the tendon of the flexor digitorum tibialis.

Bischoff[4] states that he has never found the accessorius in any anthropoid ape. But Langer,[5] Fick,[6] and Chapman[7] have found it weakly developed in the Orang. Hepburn[8] and Gratiolet and Alix[9] have found it in the Chimpanzee. Huxley[10] found it well developed in the Gorilla; it was also found in that animal by Hepburn and Macalister. As far as I am aware it has not been reported in the Gibbon. It would appear to be absent in most cases in the Gorilla. On the other hand according to Bischoff and Huxley it is present in the lower apes.

It has been suggested that the accessorius is present in young anthropoids but disappears in the old; this view is however not tenable as it has been described as absent in many young animals. Fick points out that in the foot of the Orang an accessorius muscle is not necessary, as the foot is always strongly supinated and the flexor tendons pull in a straight direction and not, as in the foot of man, obliquely. The

1 Loc. cit., Vol. II, p. 40.

2 Loc. cit., p. 186.

3 Loc. cit. 1, 231, and 2, p. 30.

4 Loc. cit. 2, p. 31.

5 Loc. cit., p. 140.

6 Loc. cit. 2, p. 304.

7 Loc. cit., p. 164.

8 Loc. cit., p. 341.

9 Loc. cit., p. 203.

10 Loc. cit., Vol. I, p. 538.

muscle undergoes considerable variation in man. Turner[1] found in two instances that the flexor accessorius had an accessory muscle attached to it which arose from the deep fascia of the back of the leg in its lower third and joined below the inner margin of the flexor accessorius. In some instances this takes the place of the deep flexor tendon in one or other of the digits, the latter tendon for that toe being absent. The number of digits to which it is distributed in man is subject to considerable variation. According to Testut the muscle may be entirely absent in man, but this one would think a rare occurrence.

The *Tibialis posticus* arose from the fibula and the tibia and the interosseous membrane in the upper third of the leg ; it was a very definite but ill-developed muscle. The muscle became tendinous at the level of the junction of the middle and lower thirds of the tibia. It then passed over the posterior aspect of the lower extremity of the tibia, lying there in a well-marked groove near the inner margin of the bone and held in place by a strong band of fibrous tissue. It was completely separated from the other tendons at the inner ankle by this band and passed under it into the sole of the foot. The muscle was inserted into the under aspect of the scaphoid bone, a slip passing to the internal, the middle, and the external cuneiform bones, and to the sheath of the peroneus longus tendon. It thus resembles the condition found in man.

The *Plantar fascia* was poorly developed, in fact hardly to be recognized as a definite structure, excepting in the posterior part of the foot. Fick also remarks on the weakness of its development. There was a very dense pad of fat and connective tissue over the heel.

The *Abductor hallucis* arose from the inner and under part of the os calcis, and was inserted into the tibial side of the base of the proximal phalanx. This muscle is well developed in anthropoids and apparently in all apes. In connection with it Langer[2] describes in the Orang a tendon which passes on to be inserted into the terminal phalanx of the great toe. This he compares to the condition found in the hand (see page 44) and considers it the representative of the flexor longus hallucis of man ; in the Gorilla he finds this tendon derived from the flexor digitorum fibularis. The muscle as described in our Orang resembles that found in man. On the right side Rudolf found underneath the abductor hallucis a small but very distinct muscle which

1 Loc. cit., p. 184.

2 Loc. cit., p. 192.

arose from the annular ligament and was inserted into the under surface of the internal cuneiform.

The *Flexor brevis hallucis.* The inner head arose from the portion of the tendon of the tibialis posticus which was inserted into the external cuneiform bone and from the sheath of the peroneus longus. It formed a well developed muscle 1.5 cm. wide, and was inserted into the base of the proximal phalanx of the great toe on its under and fibular side.

The outer head (Interosseus primus volaris of Henle) was definitely demonstrated as a structure composed wholly of fleshy fibres .5 cm. wide arising from the base of the fibular portion of the first metatarsal bone and inserted into the outer aspect of the base of the proximal phalanx of the great toe, immediately under the insertion of the adductor obliquus. The outer head of the flexor brevis in anthropoids is weak and tends to unite with the adductor hallucis more or less intimately—thus Bischoff found it in the Gorilla.

The *Opponens hallucis* was well developed. It arose in common with the flexor brevis hallucis, but proceeded separately to its insertion into the whole length of the tibial border of the first metatarsal bone. Rudolf observed on the right foot that the opponens could naturally be split up into three more or less separate and distinct fasciculi or bundles. The opponens hallucis is very variable in its development in apes. Bischoff states[1] that he only found it as a separate muscle in the Orang among anthropoids and in Macacus among lower apes. Huxley[2] discovered it in the Orang, and speaks of it as "a most remarkable muscle." At the time he writes (1864), he remarks that "this has not been described by other authors nor indeed is there any trustworthy evidence of the existence of such a muscle in any of the mammalia." Macalister, however,[3] subsequently found an opponens hallucis in the Gorilla although others have failed to find it in any of the anthropoid apes save the Orang. Brooks[4] records that whilst it is absent in all anthropoids (with the exception of the Orang) some of the fibres of the adductor transversus (and sometimes also of the adductor obliquus) in anthropoids are inserted into the metatarsal bone of the hallux and constitute a "second opponens" corresponding to the "adductor opponens" described by Bischoff and Langer in the hand of the Orang. (See page 46.)

1 Loc. cit. 2, p. 235.
2 Loc. cit., Vol. I, p. 596.
3 Loc. cit., p. 506.
4 Loc. cit., p. 90.

The opponens hallucis is not always present in the Orang, and oftentimes it is extremely weak. Testut states that an opponens is sometimes found in man. "On trouve quelquefois, au-dessous de lui (*i.e.*, brevis hallucis), quelques fibres profondes, insérées sur le metatarsien et constituant un veritable *opposant du gros orteil*, homologue de l'opposant du pouce ; mais ce muscle est rarement bien différencié."[1]

The *Adductor obliquus hallucis* and the *Adductor transversus hallucis* had a continuous origin from the bases of the third, fourth and fifth metatarsal bones, from the fascia over the interossei muscles, from the sheath of the peroneus longus and from a fibrous arch extending from the base of the fifth metatarsal to the middle of the second metatarsal bone. These muscles are inserted into the whole of the fibular and the greater part of the plantar aspect of the base of the proximal phalanx. The transverse and oblique muscles could be readily separated from one another, and a third portion was defined which had an insertion into the lower border of the first metatarsal bone. This, no doubt, represented the "second opponens" described by Brooks as derived from the adductor obliquus.

Fick[2] holds that the main function of the adductor hallucis in the Orang is opposition and not adduction. Brooks[3] describes in the Orang a portion of the adductor obliquus (inseparable at its origin from the rest of that muscle), which ended in a rounded tendon and which passed between the two heads of the flexor brevis, and running along in a well marked sheath in the middle line of the digit, was inserted into the base of the ungual phalanx. It took the place of the absent long flexor tendon. This may be compared with the description of similar conditions found in the hand of anthropoids and already noted (p. 44). A somewhat similar tendon is described by Gratiolet and Alix[4] in the Chimpanzee and the Orang ; the muscle arose along with the adductor transversus, and, passing over the proximal phalanx, was inserted into the base of the last phalanx. It was looked upon by these authors as representing the long flexor. Bischoff found in the Frankfort Orang on the left side a small tendon which in course and insertion corresponded to the flexor longus hallucis, but it arose from the fascia over the ball of the great toe.[5]

The tendency for intimate connection of the adductor hallucis with

1 Loc. cit., Vol. I, Pt. 2, p. 882.

2 Loc. cit. 1, p. 47.

3 Loc. cit., p. 87.

4 Loc. cit., p. 102.

5 Loc. cit. 1, p. 234.

the outer head of the flexor brevis has already been alluded to. Regarding the development of the transverse and the oblique adductor. Bischoff states that in the Gorilla, the Orang, Cynocephalus and Cercopithecia, both muscles are strongly developed and are separate from one another, whilst in the Chimpanzee, Gibbon, Pithecia and Hapale they are both present but united. In Macacus they are both present but weak.

The *Abductor minimi digiti* arose from the under aspect of the os calcis by two heads, one from the inner and one from the outer aspect of the bone, the inner head passing on the deep aspect of the flexor brevis digitorum. The muscle is also intimately united to the tendon of the peroneus brevis in the sole, from which it may be said to have an additional origin. This muscle terminated in a long tendinous structure which was inserted with the dorsal extensor expansion over the base of the proximal phalanx, and was attached also to the outer aspect of the proximal phalanx.

The *Abductor ossis metacarpi quinti* referred to on page 10, is closely associated with the abductor minimi digiti. It arose from the under aspect of the os calcis in common with the outer part of the flexor brevis digitorum and immediately overlying the inner head of the abductor minimi digiti. This structure is almost wholly tendinous in character. It was inserted into the outer and under aspect of the base of the fifth metatarsal bone.

The *Flexor brevis minimi digiti* arose from the base of the fifth metatarsal bone, and was inserted into the outer aspect of the base of the proximal phalanx. Rudolf on the right side found a slip of origin from the cuboid.

The *Opponens minimi digiti* arose from the sheath of the peroneus longus, and was inserted into the whole length of the fifth metatarsal bone along its outer aspect. The muscle was not found by Fick in the Orang. Bischoff[1] found it in the Gorilla.

The *Interossei* correspond in their detailed description to those of the hand. The third digit possessed two dorsal interossei lying in the interosseous spaces between the second and third and the third and fourth metatarsal bones. They arose from the dorsal surface and lateral margins of the two adjacent metatarsals; but, in addition, each is joined by a fleshy belly arising from the plantar and lateral aspects of the third metatarsal bone, the fleshy bellies of the two muscles meeting in the plantar aspect of the bone. Thus the third metatarsal bone is com-

1 Loc. cit. 2, p. 32.

pletely surrounded by the second and third dorsal interossei, with the exception of a narrow strip in the middle line on the dorsal aspect of the bone which is free from muscular fibres.

The fourth dorsal interosseous muscle arose in a similar fashion from the fourth and fifth metatarsal bones, but the third plantar interosseous takes the place of the plantar part of the fourth dorsal interosseous on the inner and plantar surfaces of the fifth metatarsal bone. The plantar portion of the second dorsal interosseous muscle is, in like manner, replaced by the first plantar interosseous on the second digit. The plantar portion of the third dorsal interosseous muscle is in like manner replaced by the second plantar interosseous muscle in relation to the fourth digit.

The first dorsal interosseous muscle is very powerfully developed. Its origin from the first metatarsal bone, however, is confined to the base of the bone. Some slips of origin from the internal cuneiform also join this head. The outer head of this muscle has an extensive origin from the second metatarsal bone, completely covering that bone, in fact, on its inner surface, and extending to the middle line on its plantar and dorsal surfaces, meeting on the plantar surface with the first plantar interosseous. Between the two heads of this muscle the dorsal vessels pass to the dorsum of the foot.

Fick[1] describes the intereossei in the Orang as like those found in man. In both man and apes one finds that one digit in both hand and foot possesses an insertion of two dorsal interossei, whilst the remaining digits possess only one dorsal interosseous muscle. In man it is the third digit in the hand, and the second digit in the foot; whilst, in my Orang, it was the third digit in both hand and foot. In this respect, the foot of my Orang corresponded to the hand of either ape or man, and differed from the foot of man. Abduction or adduction in the foot of my Orang was from or to the third digit. Bischoff, in his first paper, asserts[2] that in all apes the arrangement of the interossei of the foot corresponds to the hand of man and apes ; but, subsequently, he found in the Gorilla an arrangement corresponding to the foot of man. Hepburn[4] found that abduction of the digits of the foot was from a line drawn through the second digit in the Gorilla and Chimpanzee, whilst in the Orang and Gibbon it was from a line through the third digit, as in my Orang.

1 Loc. cit. 1, p. 47.

2 Loc. cit. 1, p. 235.

3 Loc. cit. 2, p. 32.

4 Loc. cit., p. 347.

Gratiolet and Alix[1] differed from Hepburn regarding the Chimpanzee, as they found abduction was from a line drawn through the third digit. Thus, there is apparently some variation among the anthropoid apes, but the most common arrangement is abduction from a line through the third digit, and this, as far as my observation has extended, has always been found to be the case in the Orang, excepting in Fick's example mentioned above.

Attention has already been directed to the fact that the foot of the Orang resembles, in outward appearance, the human hand rather than the human foot. This observation led naturalists to apply the term "quadrumanous" to those apes possessing such characteristics. The external characters of the foot of the Orang certainly suggest a hand rather than a foot. Further, the foot of the Orang differs very materially in its external characters from that of man (compare the photographs of the hand and foot of man with those of the Orang). In considering the question as to whether the posterior extremity of the Orang possesses a hand or a foot, we must constantly have in mind the characteristic features of the human hand and the human foot with which to institute comparisons. It is not necessary to discuss at length the correspondences which are found in comparing the hand with the foot, but certain of the more obvious of these may be alluded to, and one is greatly aided in thus establishing homologies in man by reference to the lower animals. In the hand we have five digits as in the foot, and we find that the bones of the fingers and toes, *i.e.*, the metatarsals and metacarpals, with the phalanges, correspond in number, and have sufficient individual resemblances to make it an easy task to recognize those bones of the hand which correspond to similar ones in the foot. The carpal and tarsal bones are not so readily distinguished, but by referring both series of bones to a less specialized type of carpus and tarsus, one is able to establish very readily a series of probable homologies. The carpus or tarsus of the water tortoise has been suggested by Gegenbaur and Oscar Schmidt[2] for this purpose, and by referring the bones of the foot and hand to this simple form, we can determine the corresponding structures. In the following table, taken from Quain's Anatomy,[3] an attempt is made to establish these homologies. The "typical names" here employed refer to the bones in the carpus or tarsus of such a generalized form as the water tortoise:—

1 Loc. cit., p. 190.

2 Oscar Schmidt. "The Mammalia in their Relation to Primeval Times." London, 1895, p 36.

3 Vol. II, Part I, p. 144.

TABLE OF THE HOMOLOGOUS BONES OF THE CARPUS AND TARSUS.

Carpus.	*Typical Names.*		*Tarsus.*
Pyramidal	Ulnare	Fibulare	Os calcis
Pisiform	Ulnare sesamoideum(?)	Fibulare sesamoideum(?)	Os calcis
Lunar	Intermedium	Intermedium	Astragulus
Scaphoid	Radiale	Tibiale	Astragulus
Scaphoid	Radiale sesamoideum (?)	Tibiale sesamoideum (?)	Navicular
Scaphoid	Centrale	Centrale	Navicular
Trapezium	Carpale 1	Tarsale 1	Internal cuneiform
Trapezoid	Carpale 2	Tarsale 2	Middle cuneiform
Magnum	Carpale 3	Tarsale 3	External cuneiform
Unciform	Carpale 4	Tarsale 4	Cuboid
Unciform	Carpale 5	Tarsale 5	Cuboid

Thus it would appear that in the skeleton we have corresponding elements to deal with when we compare the hand with the foot. Again in connection with the soft parts it is quite obvious that many muscles in the foot are represented by corresponding structures in the hand. There is, however, room for considerable difference of opinion regarding homologies here, and whilst we are unable to go into this subject at length in this paper, we may consider it briefly.

Broadly speaking, the flexor group of muscles in the leg may be regarded as homologues of the flexor group in the forearm, and the extensors of the leg as homologues of the extensors of the forearm. Huxley[1] suggested, with apparently good reason, that the popliteus of the leg arising from the external condyle of the femur corresponded to the pronator radii teres arising from the internal humeral condyle ; the fact that the external femoral condyle is the homologue of the internal humeral condyle being readily established by tracing the difference in direction of the rotation of the limbs in development. We find that pronation and supination are movements not possible in the leg, although Bischoff[2] considers the peroneus longus and brevis to be pronators of the foot by raising its outer margin. He is therefore inclined to regard these muscles as performing similar functions to the pronators of the forearm in their action upon the hand ; similarly he would regard the tibialis anticus as a supinator in the foot. These muscles, however (peronei and tibialis anticus), have as homologues in the forearm, according to Bischoff, the extensor carpi ulnaris and the two radial extensors, but these fail to raise the inner or outer margin of the hand as this movement is accomplished by pronation and supination of the hand as a whole. Bischoff would have us believe that whilst it is possible to establish

1 Loc. cit., Vol. I, p. 203.

2 Loc. cit. 1, p. 236-7.

analogues and homologues for other muscles, the movements of pronation and supination in the forearm must be regarded as being performed by muscles which have no homologues in the leg. The suggestion of Melzer (see p. 63 of this paper), deserves mention in this connection. He regards the humeral head of the pronator radii teres as being represented by the external head of the gastrocnemius, whilst the ulnar head, he claims, is represented by the popliteus. I, however, accept Huxley's view as the correct one and look upon the pronator radii teres of the forearm as the homologue of the popliteus in the leg. Melzer's view is not tenable; there is good reason to look upon the gastrocnemius muscle as representing the flexor carpi radialis and the flexor carpi ulnaris of the forearm.

Huxley[1] asserts that the foot of man is distinguished from his hand by the following absolute anatomical differences:

1. By the arrangement of the tarsal bones.
2. By having a short flexor and a short extensor muscle of the digits.
3. By possessing the muscle termed peroneus longus.

Bischoff[2] questions the correctness of Huxley's assertion. He considers that both peronei muscles together form a muscle which has become doubled in the foot and represents, as we have stated, the single extensor carpi ulnaris in the hand. In similar fashion he considers that the single muscle which we describe as the tibialis anticus in the foot is doubled in the hand, being there represented by the extensores carpi radialis longior et brevior. Huxley, however, has shown conclusively that the tibialis anticus corresponds to the extensor ossis metacarpi pollicis (abductor longus pollicis). There can be no doubt of this; the former is inserted into the first metatarsal bone and the internal cuneiform, whilst the latter is inserted into the first metacarpal bone and the trapezium.

The distinctive difference which Huxley claims for the foot in possessing the short extensor and the short flexor is denied by Bischoff, who concludes that if we contrast these muscles with the tendons which we describe under the terms "perforans" and "perforatus" in the hand, we shall find homologous structures, but we may go further, and we find it easy to produce evidence to lead us to the

1 Huxley, "Evidences as to Man's Place in Nature." New York, 1890, p. 107.
2 Loc. cit. 1, p. 236-7.

conclusion that the flexor sublimis digitorum of the hand has as its homologue in the foot the flexor brevis digitorum and the soleus, the latter muscle having been separated from the former by the growth backwards of the os calcis. Again in the case of the extensor brevis digitorum pedis we have in the hand as homologous structures the extensor minimi digiti and the extensor indicis. Huxley himself[1] in discussing these two muscles in the Orang, called attention to the fact that in many of the lower mammalia the normal arrangement is to have a superficial and a deep extensor supplied to every digit. This arrangement is approached when we find, as in my Orang, the extensor minimi digiti passing to the fourth and fifth digits, and the extensor indicis passing to the second and third digits. In the dissecting room of the University of Toronto, I found, in the human subject, an extensor indicis for the second digit, and an extensor minimi digiti for the fifth digit, whilst a very well developed muscular slip (1 cm. wide), arose from the ligaments over the back of the carpus, and proceeding over the dorsum of the middle finger beneath the tendon of the common extensor, it split at the head of the metacarpal bone and blended with the extensor expansion on the dorsum of the proximal phalanx. This was a true extensor brevis occurring in the hand of man.

The supinators (longus and brevis) do not appear to have any representatives in the lower limbs, nor do the two radial extensors. So, too, we have structures in the foot not represented in the hand, of which the flexor accessorius is an example. One has observed the fact that the foot of the ape frequently differs from the foot of man in that the accessorius is often absent in the former. It is usually absent in anthropoids (although present on the right side of my Orang) : it is present however in the lower apes. Bischoff[2] points out that in man it corrects the direction of the action of the flexor digitorum longus communis, otherwise the direction of the pull of the long flexor would be at an angle. In the foot of the ape this is of no importance, on the contrary the action of the flexor tendons in adducting the other toes to the great toe is of great service in seizing or grasping. The toes of the apes in their flexor arrangements would thus resemble fingers much more than toes.

Although difficulties arise in the attempt to establish homologies, yet on the whole it would appear that a remarkable correspondence is obvious when we compare the musculature of the forearm with that of the leg. This is further evidenced in a most remarkable manner if we

1 Loc. cit., Vol. I, p. 596.

2 Loc. cit. 1, p. 257.

direct our attention to the muscles which Cunningham has called the "intrinsic muscles of the foot" when compared with a similar group of muscles in the hand. We find that homologies are best established here by referring the muscles of the hand or foot in man to a more generalized type and through the arrangement there found we may institute comparisons and establish homologies. Cunningham has done this for us in his work upon the marsupials.

One is aided greatly in appreciating the morphological significance of these muscles by reference to the conditions obtaining in the foot and hand of apes and mammals lower in the scale. Reviewing briefly Cunningham's observations on the subject we may first of all state that Cunningham[1] excludes from the intrinsic group those muscles which in man, or as homologous structures in other animals, take origin beyond the limits of the foot, and in the human foot he gives the following list of intrinsic muscles :

a. The four short muscles of the Great Toe.
1. Flexor brevis hallucis.
2. Abductor hallucis.
3. Adductor hallucis (adductor obliquus.)
4. Transversalis pedis (adductor transversus.)

b. The short muscles of the little toe......
1. Flexor brevis minimi digiti.
2. Abductor minimi digiti.
3. The occasional opponens minimi digiti.
4. The occasional abductor ossis metatarsi minimi digiti.

c. The Interossei..
1. Four dorsal.
2. Three plantar.

In establishing homologies here, we must not place too much importance upon nerve supply as an aid to correct conclusions. Thus Cunningham joins issue with Ruge of Heidelberg, who regarded a muscle as the end organ of a nerve, and that, therefore, when a muscle altered its position and connections, its origin and typical relations can always be identified by its nerve supply. Cunningham admits that nerve supply is a most valuable aid to one's endeavours to discover the history of a muscle, but that it is an infallible guide is contrary to fact. In this connection Cunningham observes[2] that wherever two nerves approach one another and reach the confines of their distribution there is a tendency to variation in nerve supply. He quotes Brooks' results as to his investigation regarding the variation in nerve supply of the flexor brevis pollicis in man, thus—

1 Loc. cit., (Marsupial Report), p. 48.

2 Cunningham, "The Flexor Brevis Pollicis and the Flexor Brevis Hallucis in Man." Anatomischer Anzeiger VII, 1892, p. 206.

Outer head supplied by the deep branch of ulnar alone	5 cases.
" " " twigs from ulnar and median	19 "
" " " median, inner by the ulnar	5 "
Median nerve, giving twigs to both heads, inner head also receiving an ulnar supply	2 "

In a careful study of the muscles of the feet of certain of the marsupials, Cunningham demonstrates three layers, and concludes that this trilaminar arrangement is the typical one for the intrinsic muscles of the foot and the hand.

1. A layer of adductores.
2. An intermediate layer of flexores breves.
3. A dorsal layer of abductores.

Young[1] has also investigated the intrinsic muscles in the foot and hand of marsupials and agrees with Cunningham in his observations on the trilaminar arrangement; he extended his observations to other members of the group than those dissected by Cunningham.

Cunningham explains that deviation from this trilaminar arrangement may occur by subdivision, fusion or suppression of members of one or other of the layers. The suppression may be complete or partial and the muscle may be represented by ligaments.

In transferring our attention to the conditions obtaining in the ape we can readily determine the trilaminar arrangement and we observe that either the muscle group in the hand or that in the foot corresponds to this typical arrangement. Thus by reference to Plate 3 one can readily distinguish the three layers in the hand of my Orang.

1. Fig. 5 shows the muscles of the palmar layer composed of the adductor muscles of the thumb.

2. Fig. 6 demonstrates certain of the flexores breves of the intermediate layer.

3. Fig. 7 shows the dorsal layer of the abductores.

As I have already stated, so far as the so-called " interossei " are concerned, the condition found in the foot of my Orang corresponded to that found in the hand in every particular, and in plate V is illustrated the arrangement of these muscles in either foot or hand.

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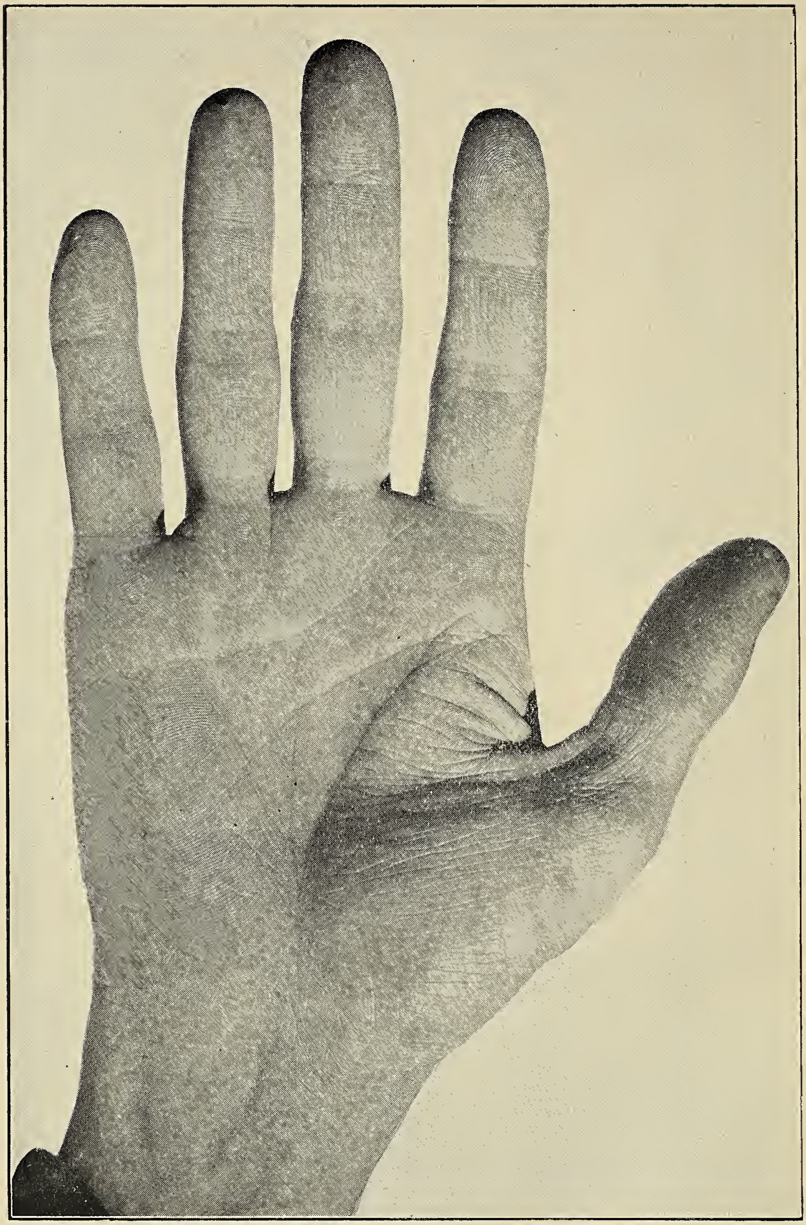
1 A. H. Young, "The Intrinsic Muscles of the Marsupial Hand." Journ. of Anat. and Phys. Vol. XIV, 1879, p. 149.



From a photograph of the palm of the hand of an adult man, showing the markings on the palm of the human hand.

From a photograph of the palm of the hand of the Orang Outang, showing the markings on the integument of the palm.

The dorsal layer of muscles is represented by a full series ; the four dorsal interossei and with them the abductor pollicis and the abductor minimi digiti. It is interesting here to note the suggestion that the abductor of the thumb and the little finger each arise from marginal structures which have been looked upon as possibly præpollex and postminimus rudiments, viz., the ridge (or margin) of the trapezium and the pisiform bone. From this standpoint they have been regarded as interossei muscles which have persisted after the suppression of the osseous elements of the additional digits. I have already noted the relation of the extensor ossis metacarpi pollicis to the præpollex, and in this connection one may note an interesting variation of that muscle which I found in the dissecting room of the University of Toronto. The extensor ossis metacarpi pollicis split into two distinct tendons at a point 5 cm. above the wrist joint ; one tendon was inserted into the base of the metacarpal bone in its palmar aspect, and the other passed on to join the abductor pollicis and could be traced as a distinct tendon extending 2 cm. along the deep aspect of that muscle, where it blended with its muscular fibres.

We have thus in the hand the following muscles in the *dorsal layer.*

1. Abductor pollicis.

2. Abductor minimi digiti.

3. The Dorsal interossei.

In the foot Cunningham adds a fourth muscle occasionally present, a rudiment of which I have described in my Orang, viz. :

4. The occasional Abductor ossis metatarsi minimi digiti.

The second layer of muscles, the intermediate layer, is made up of those muscles which Cunningham has termed the Flexores breves in the marsupials. These in man, as in the Orang, include the plantar interossei and the short flexors of the thumb and of the little finger. Cunningham[1] at first was inclined to place the plantar interossei in the plantar group of adductors, but he subsequently placed them in the intermediate layer for the following reasons :

1. In quadrumana he has traced the gradual disappearance of the adductor muscles except those belonging to the great toe.

2. We find plantar interossei not only in those apes which have

1 D. J. Cunningham, "The Intrinsic Muscles of Thylacine, Cuscus and Phascogale." Journ. Anat. and Phys., Vol. XII, 1878, p. 434.

complete adducting apparatus (*e.g.*, Cynocephalus) but also in those in which it is only represented by the adductors of the hallux and by fibrous bands (*e.g.* Orang) and in those in which it is reduced to the adductors of the great toe only (*e.g.* Gorilla).

3. Ruge has pointed out that the deep division of the external plantar nerve, as it runs inwards across the sole is placed between the adductor muscles and the other muscles of the intrinsic group. This is a most useful, and, as a general rule, a most reliable guide in determining the muscles which belong to the plantar layer. Ruge[1] points out that in mammals the deep division of the external plantar passes inwards between the interossei and the contrahentes (adductors). In man this nerve passes between the plantar interossei beneath and the adductor obliquus hallucis above, and this Cunningham looks upon as most suggestive.

4. In a foot dissected by Cunningham he found a distinct fleshy slip proceeding from the outer edge of the adductor obliquus hallucis to be inserted into the outer side of the base of the first phalanx of the index. This clearly represented the adductor indicis.

Cunningham would therefore place in the intermediate layer the following muscles:

1. Flexor brevis pollicis, deep and superficial heads.
2. Flexor brevis minimi digiti.
3. Plantar interossei.

In studying the interossei group (palmar and dorsal), as found in my Orang, and figured in Plate V, it appears to be a question worth considering as to the relation of the palmar portion of the dorsal interossei to the intermediate layer. On reference to the dissection (as figured in plate V), one cannot but be struck by the symmetrical arrangement of the palmar interossei and the palmar portion of the dorsal interossei as forming one group of flexores breves, and the origin of the palmar interossei may yet be accounted for by subdivision of originally single muscles, or we may suppose that fusion has occurred to produce the connection of the palmar portion with the remaining part of the dorsal interossei. In other words one would venture to suggest that the intermediate layer is represented in the Orang by the palmar interossei

1 G. Ruge, "Zur vergleichenden Anatomie der tiefen Muskeln in der Fusssole." Morphologisches Jahrbuch, Vol. IV, 1878, p. 644.

plus the palmar portion of the dorsal interossei, and the short flexors of the thumb and little finger.

The flexor brevis of the first digit is represented by two heads, of which the deep head might otherwise be described as one of the palmar or plantar interossei, the interosseus primus volaris of Henle. This muscle resembling in its attachments and relations the other muscles of the plantar interosseous group, belongs to the intermediate layer.

The common origin of all these muscles of the interosseous group is indicated by Huxley[1] who states that amongst the Platyrrhini the interossei are no longer visible from the dorsum of the foot, but, as in the lower mammals, are altogether flexores breves inserted by sesamoid bones into the bases of the first phalanges. This resembles the condition described by Ruge in the human foetus (vide infra).

We have still left for consideration a series of muscles representing the adductor group. In the Orang, as in man, these are reduced to the adductors for the first digit. Thus we have in the hand the adductor obliquus pollicis and the adductor transversus pollicis. These represent a more extensive series found in marsupials in the plantar layer as adductors of the second, fourth and fifth digits. In the Chimpanzee and Gibbon there are two adductors, viz., for the first and fifth digits, whilst in the Orang and Gorilla the adductor for the first digit alone remains.

Thus in man and in the orang we have, in the palmar layer, the adductors of the thumb (obliquus and transversus),

Adductor obliquus pollicis.

Adductor transversus pollicis.

The only short muscles of the first and fifth digits, which we have not accounted for, are of the opponens group. In my Orang we found an opponens for the first and fifth digits in both hand and foot. These Cunningham considers as developed most commonly from the flexores breves group.

Our complete classification would therefore be:

Dorsal layer.

1. Abductor pollicis.

2. Abductor minimi digiti.

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1 Loc. cit., Vol. II, p. 94.

3. Dorsal interossei.

and in the foot occasionally

4. Abductor ossis metatarsi minimi digiti.

Intermediate layer.

1. Flexor brevis pollicis { deep head. / superficial head.

2. Flexor brevis minimi digiti.

3. Plantar interossei.

4. Opponens.

Palmar layer.

Adductor Pollicis { obliquus. / transversus.

We can now readily establish homologies for the hand and foot, and we may construct a table thus:

Flexor brevis pollicis	Flexor brevis hallucis
(*a*) Radial head	(*a*) Tibial head
(*b*) Ulnar head	(*b*) Fibular head
Flexor brevis minimi digiti	Flexor brevis minimi digiti
Abductor pollicis	Abductor hallucis
Abductor minimi digiti	Abductor minimi digiti
Opponens pollicis	*Opponens hallucis*
Opponens minimi digiti	Opponens minimi digiti
Adductor obliquus pollicis	Adductor obliquus hallucis
Adductor transversus pollicis	Adductor transversus hallucis
Interossei (Palmar and Dorsal)	Interossei (Plantar and Dorsal).

Homologies are thus established for the limb muscles, as has been done also for the skeletal parts; one may add that an attempt is also made to establish homologies for the nerves (*vide* Quain, Vol. III., Pt. 3, p. 384). I shall not, however, attempt to discuss the homologies of the nerves in this paper. Whilst we can thus establish homologies between the structural elements of the hand and foot, we yet observe certain anatomical differences due, I consider, to modification from a common type of origin. The foot of man is modified as an organ for support, whilst the hand of man, in the erect attitude of the individual, is left free to minister to his varied needs. There can be little doubt concerning the correctness of the view that these two extremities are derived from a common type and that the differences observable between the hand and the foot are due to modification resulting in departure from the original typical form, these modifications being due to a specialization of function—one holds this view despite the fact that Bischoff comes to the conclusion that both anatomically and physiologically the so-called posterior hand of the ape possesses more agreement with the human hand than with the human foot.

No doubt certain conditions in the ape's foot resemble the conditions present in the hand, and differ from those of the human foot. The adductor transversus hallucis in the ape's foot tends to blend with the adductor obliquus and is much more strongly developed than in the human foot. In this particular the muscle in the ape's foot approaches that found in the hand of man and differs from the human foot. In my Orang I found an opponens hallucis ; this muscle is not always found in anthropoids, but appears to be peculiar to the Orang, and among lower apes it is found in Macacus. This is a characteristic muscle of the hand and is not found in the human foot. Among apes there is a frequent approach to the hand (as in my Orang), in the arrangement of the interossei, whereby abduction is secured from the third digit and not from the second. Huxley[1] admits that the foot of the Orang deviates very greatly from that of man. The great length of the phalangeal portion of the foot is very noticeable, and the narrow os calcis with an absence of the two tubercles which are present in man. There is great mobility between the carpal bones; the phalanges are greatly curved. The hallux is remarkably short,and is capable of extreme abduction from the other digits, whilst opposition is also possible to a complete degree. In connection with the movableness of the great toe in apes one is struck by the peculiarity of the shape of the articulation between the first metatarsal bone and the internal cuneiform. The articular surfaces are saddle-shaped, and thus provide for greater freedom of movement. This differs from the foot of man where the surfaces are flat and is in agreement with the hand of man where the characteristic saddle-shaped joint is found between the trapezium and the first metacarpal. This condition in the ape was described by Huxley in the Chimpanzee's foot, and it was also noted by Huxley that, in the hand, the trapezium in that animal presented a simple, oval, convex facet, and was no longer saddle-shaped.[2] In the lower apes, however, Huxley found the characteristic saddle shape of the trapezium.[3] Fick describes this joint of the first digit as being saddle-shaped in both foot and hand in the Orang;[4] Bis-

1 Loc. cit., Vol. I, p. 564.

2 Loc. cit., Vol, I, p. 428.

3 Loc. cit., Vol. I, p. 671.

4 Loc. cit. 1, p. 50.

choff in the Gibbon, however, describes a hollowed out socket in the trapezium for the head of the metacarpal bone, but says the joint was not a true saddle-shaped articulation.

The flexor accessorius is a characteristic feature in the human foot. We have already noted the fact that it is very frequently absent, and always ill-developed in the anthropoid apès. When we consider that its development is almost universal among the lower apes, it is not to be looked upon as an essential difference between man and apes; when absent, however, the inferior extremity of the anthropoid ape rather resembles the hand of man than his foot.

The strong well developed flexor longus hallucis is a characteristic feature of the human foot not found in apes. The Gorilla is an exception to this statement, as Bischoff and Duvernoy found a well developed strong tendon for the great toe in that animal. In the Orang the flexor longus hallucis gives no tendon to the great toe, whilst in other apes its distribution is mainly to the third and fourth toes, with usually a very weak slip for the hallux.

Whilst the ape's foot thus differs from the foot of man, it is also quite obvious that the hand also differs in a marked degree from the human hand. Compare (see photograph) the long thin hand of the ape with that of man, and note particularly the rudimentary thumb. The thumb is extremely rudimentary and ill-developed. It becomes still more so in the new world monkeys, according to Huxley[1]; in Ateles it is apparently functionless, although all its muscles (abductor, adductor, flexor brevis and opponens) are present, except the long flexor. In the Arctopithecini (marmosets) Huxley[2] says it can no longer be called a thumb; the digit lies on the same plane as the other digits and is not in the least degree opposable—this might be called a paw rather than a hand—whilst such is the case, the hallux, which is very small, is still slightly opposable in this animal.

The absence of a flexor longus pollicis, so strongly developed in man, is obviously a very marked and essential difference observable in comparing the hand of the ape. Again we have noted the absence of the characteristic saddle-shaped articular surface in the joint between the first metacarpal and the trapezium.

A fact of some interest regarding the comparisons which may be

1 Huxley, "Manual of Anatomy of Vertebrated Animals," New York, 1872, p. 396.

2 Loc. cit., Vol. II, p. 124.

established between the ape and man is one to which we have already called attention, namely, that in the human fœtus we find correspondences more marked than they are when the adult man is compared with the ape. Cunningham mentions Ruge's work in the following reference.[1] "Ruge in his memoir upon the development of the muscles of the human foot shows that the interossei muscles in the foot of the early embryo are plantar in position, and that the upward growth of the dorsal interossei and the formation of the interosseous spaces takes place as a subsequent and gradual step. In three of the diagrams which illustrate the text he gives representations by sections through the metatarsus at three different periods of development. In the first the metatarsal bones, with the exception of the first two, are in close apposition, and in consequence, all the interosseous muscles, excepting the first dorsal, are plantar in position. The second diagram is from a foot somewhat more advanced. It shows that as development progresses the metatarsal bones separate from each other, and that simultaneously with this the dorsal interossei begin to shoot up between them like wedges. The third illustration gives a view of the relative position of the muscles and metatarsal bones, as they are to be seen in the adult. The bones are widely apart from each other, and the muscles have reached the dorsum of the foot."

The transverse section (Plate IV, fig. 4), illustrates the fact that the interossei muscles are more plantar (palmar) than dorsal in my Orang; this condition is exaggerated in the lower apes where, as I have already stated, Huxley found among the Platyrrhini the interossei of the foot were no longer visible from the dorsum but existed as flexores breves towards the plantar surface. In the dog the metatarsals are closely compressed, and the interossei wholly plantar.

In the human fœtus the great toe is separated from the other toes and the position of the foot is that of "varus," resembling somewhat that found persistent in the ape. We find that this fact is alluded to by Flower,[2] who, in referring to the principal difference between the foot of the ape and the foot of man, emphasizes the fact that in the ape the foot is converted into a more or less modified grasping organ. He directs attention to the effect produced upon the ape's foot in consequence of the fact that the articular surface of the internal cuneiform for the hallux is saddle-shaped, and is directed obliquely towards the inner or tibial side

1 Quotation rom Cunningham's Challenger Report, p. 138-9.

2 Loc. cit., p. 341.

of the foot. The consequence is that the hallux is not only separated from the other digits, but it is also set in a different plane, so that when it is flexed it turns towards the sole of the foot and becomes opposed to the others much as the thumb does in the hand. Flower (and others, *e.g.*, Fick) remarks that the terminal phalanx of the hallux is often wanting. Fick attributes this to ill-usage. Flower points out that the proportions of the three segments of the foot in the anthropoid ape are the exact reverse of those in man. In the ape the tarsal segment is the shortest and the phalangeal the longest; the reverse is true of man.

The result of our study is to bring us to the conclusion that whether we study the extremities of man or of the Orang we find corresponding structures in the upper extremity as compared with the lower. A common type of origin is clearly indicated. This is the more readily observed in the ape than in man where the highest degree of specialization of function has been reached. As a result of this we find greater differences exist between the human hand and the human foot, than between the hand and the foot of the ape. Moreover, in man there is a greater departure from the common type of origin in both hand and foot. Bischoff has investigated the subject of homologies, and although his conclusions differ in some details from the views expressed in this paper, he agrees in the main and establishes homologies for the hand and foot of man as in the hand and foot of apes. He further admits that certain correspondences exist between the foot of the ape and the foot of man. Following Bischoff's argument to a logical conclusion (as Fick observed[1]) we would be forced to conclude that man, like the ape, had four arms and four hands. Bischoff, however, views the matter not wholly from the morphological side, but from the physiological, and, looking upon the ape's foot as a grasping organ, he considers this strong evidence for the assertion that it is a hand. He admits that this alone is not sufficient evidence ; on similar ground he says one might call the trunk of an elephant a hand, but there are obviously other similarities in the ape's foot to a hand, chiefly the short, movable, opposable hallux, differing from the first digit of the human foot, possessing the saddle joint with the internal cuneiform and thus resembling the human thumb. Whilst one cannot longer uphold in its entirety Huxley's assertion regarding the absolute anatomical differences in distinguishing the foot of man from his hand (see page 75), yet in the skeletal parts his argument regarding the arrangement of the tarsal bones is unanswerable and we are forced to conclude with him that the so-called hind hand of the ape is essentially a foot. The method of articulation of the foot with

1 Loc. cit. 1, p. 53.

the leg at the ankle joint is characteristic of the foot and not of the hand. There is also an absence of pronation and supination in the ape's foot. Langer[1] admits the resemblance of the ape's foot to a hand, but also points out the obvious fact that the anterior extremity of the Orang is as far removed from the human hand as the posterior extremity is from the human foot. Both extremities are wholly organized for holding and grasping in the ape, and Langer would have us look upon the posterior extremity as a holding or grasping foot. Huxley, it is true, argues the matter wholly from the morphological standpoint, and Fick[2] agrees with Huxley that the feet of man and apes are essentially alike in all variety of anatomical detail. But certain differences (non-essential) undoubtedly exist. The absence of a true arch and the fact that the Orang walks upon the outer margin of the foot with the digits flexed like a closed fist. In man the toes are, comparatively, very short, and as Turner points out, the great toe is fastened to the second digit by a strong ligament. The fixation of the great toe, however, may be greatly decreased in man as is evidenced in those individuals who have congenital absence of the arm; they are capable of doing many things with the toes, impossible on the part of an ordinary individual. By training, an armless painter, according to Fick, was able to copy Rubens' pictures, and one knows of the possibility of individuals writing, playing the violin, and doing a variety of things. Thus, when necessary, man is capable of using his foot for a number of purposes and to accomplish work ordinarily relegated to the hands. In the struggle for existence, similarly, the ape has developed great dexterity in the use of his foot, but it still remains a foot. Fick tells us that in the living ape there is an obvious difference in the manner in which he uses the upper and lower extremities. In walking, running and springing forwards from the hind legs the arms are scarcely burdened, but the hands are always ready to grasp an object such as fruit, and to do all finer work, such as the breaking open of fruit, seeking vermin, etc., the legs and feet being used for support and in running.

It was Tyson,[3] two centuries ago, who, struck by the great external resemblance of its hinder limb with its opposable thumb to a hand, remarked that the animals might be called "quadru-manus." Referring to the foot of the Chimpanzee which he dissected, he remarks as follows:—"But this part, in the formation and its function too, being liker a hand, than a foot, for the distinguishing this sort of animals from others,

1 Loc. cit., p. 193.

2 Loc. cit. 1, p, 53.

3 Loc. cit., p. 13.

I have thought, whether it might not be reckoned and called rather quadru-manus than quadrupes, *i.e.*, a four-handed, than a four-footed animal." Huxley remarks that if we are to settle the question on the grasping power of the organ we must consider the terminal division of the hind limb of a bird or an oppossum to be equally a hand with that of the monkey. Huxley, however, holds that morphological analogies cannot be decided by physiological function, but only by exact comparison of the essential anatomical characters. An attempt has been made in this paper to show, with due regard to both structure and function, that the ape must be considered as possessing two feet and two hands ; that the posterior extremities of the creature terminate in structures resembling both anatomically and physiologically the human foot rather than the human hand.

The comparative study of the muscles of the Orang is full of interest, and the interest increases when we institute comparisons with the arrangement of the musculature in the human body. Fick[1] holds that in the Orang we have more muscle variation (when we consider the literature), than we have in man, and it is interesting to note that in the sense of the modern view, we have in the present day Orang, evidence of a more active phylogenetic variation than in man.

By studying muscle variation in man relating to normal conditions in lower animals, we may throw light on the position of man in the animal kingdom. This conviction was long ago expressed by Professor Wood,[2] who remarked, concerning the comparative study of the musculature of man and the lower animals, that:—" If in addition to the general resemblance of the muscular mechanism, there are to be found in the former [*i.e.*, in man] fragmentary records of special apparatus which have, in the latter [*i.e.*, in lower animals] the fuller development of a definite purpose, then these may be taken as at least of equal importance with other evidence of traces, some may think, of a general unity of plan with varied teleological intentions, and others, of an ancient morphological relationship of a much closer character. But if, on the other hand, muscles are found which have no place in the various animal types, we may fairly take them as indications, valuable as far as they go, of progress still advancing towards a higher development of the human frame, —of an increase in the distance, already great, which separates physically man from animals."

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1 Loc. cit. 2, p. 306.

2 Loc. cit., p. 44.

EXPLANATION OF PLATES.

The following plates are drawings from dissections made by the author:—

PLATE III.

FIG. 1.—Dissection of the posterior aspect of the neck and shoulder of the Orang Outang.

acrom., acromion process; *clav.*, clavicle; *e.a.m.*, external auditory meatus; *i.spin.*, infra spinatus; *l.a.s.*, levator anguli scapulae; *m.o.*, omo cervicalis; *rhom.*, rhomboid; *s. spin.*, supra spinatus; *s. mag.*, serratus magnus; *trap.*, trapezius; *t. min.*, teres minor.

PLATE IV.

FIG. 2.—Dissection of the anterior aspect of the chest wall and shoulder of the Orang Outang.

acrom., acromion process; *clav.*, clavicle; *cor.*, coracoid process; *Delt.*, deltoid; *H.*, humerus; *p. min.*, pectoralis minor; *p. m.* 1, the pars costo-abdominalis of the pectoralis major; *p.m.* 2, the pars sterno-costalis of the pectoralis major; *p.m.* 3, the pars sternalis of the pectoralis major. *S. m.*, sterno mastoid.

FIG. 3.—Representation of the mode of insertion of the pectoralis minor muscle.

acrom., acromion process; *clav.*, clavicle; *cor.*, coracoid process; *lig.* 1 and *lig.* 2, continuation of the fibres of insertion of the pectoralis minor muscle into the clavicle and the acromion process; *p. min.*, the tendon of insertion of the pectoralis minor muscle passing to the coracoid process.

FIG. 4.—The arrangement of the interossei muscles in the Orang Outang, as they appear in their relation to the metacarpal bones, on transverse section through the metacarpus.

d. i., dorsal interossei; *v. i.*, palmar interossei.

PLATE V.

FIG. 5.—Dissection of the short muscles of the thumb and the little finger in the Orang Outang.

ab.m.d., abductor minimi digiti; *ab.P.*, abductor pollicis; *ad.o.p.*, adductor obliquus pollicis; *a.t.p.*, adductor transversus pollicis; *F.*, palmar fascia; *f.b.p.* 1, *f.b.p.* 2, outer and inner heads of the flexor brevis pollicis; *fl.b.m.d.*, flexor brevis minimi digiti; *op.m.d.*, opponens minimi digiti; *o.p.*, opponens pollicis.

FIG. 6.—Dissection of the interossei muscles of the hand in the Orang Outang, viewed from the palmar aspect.

v.i. 1, *v.i.* 2, *v.i.* 3, palmar interossei, *d.i.* 1, *d.i.* 2, *d.i.* 3, *d.i.* 4, dorsal interossei.

FIG. 7.—Dissection of the interossei muscles of the hand in the Orang Outang, viewed from the dorsal aspect.

v.i. 1, *v.i.* 2, *v.i.* 3, palmar interossei, *d.i.* 1, *d.i.* 2, *d.i.* 3, *d.i.* 4, dorsal interossei.

PLATE VI.

FIG 8.—Dissection of the gluteal region, and the back and outer side of thigh in the Orang Outang.

g.max., gluteus maximus; *g.med.*, gluteus medius; *g.min.*, gluteus minimus; *g.s.n.*, great sciatic nerve; *g.troch.*, great trochanter of the femur; *h.m.*, hamstring muscles; *ib.*, iliac bone; *il.*, iliacus; *is.*, ischial spine; *ob.e.*, obturator externus; *ob.i.*, obturator internus; *py.r.*, pyriformis; *q.f.*, quadratus femoris; *rect.*, rectus femoris; *scan.*, scansorius; *v i* vastus externus.

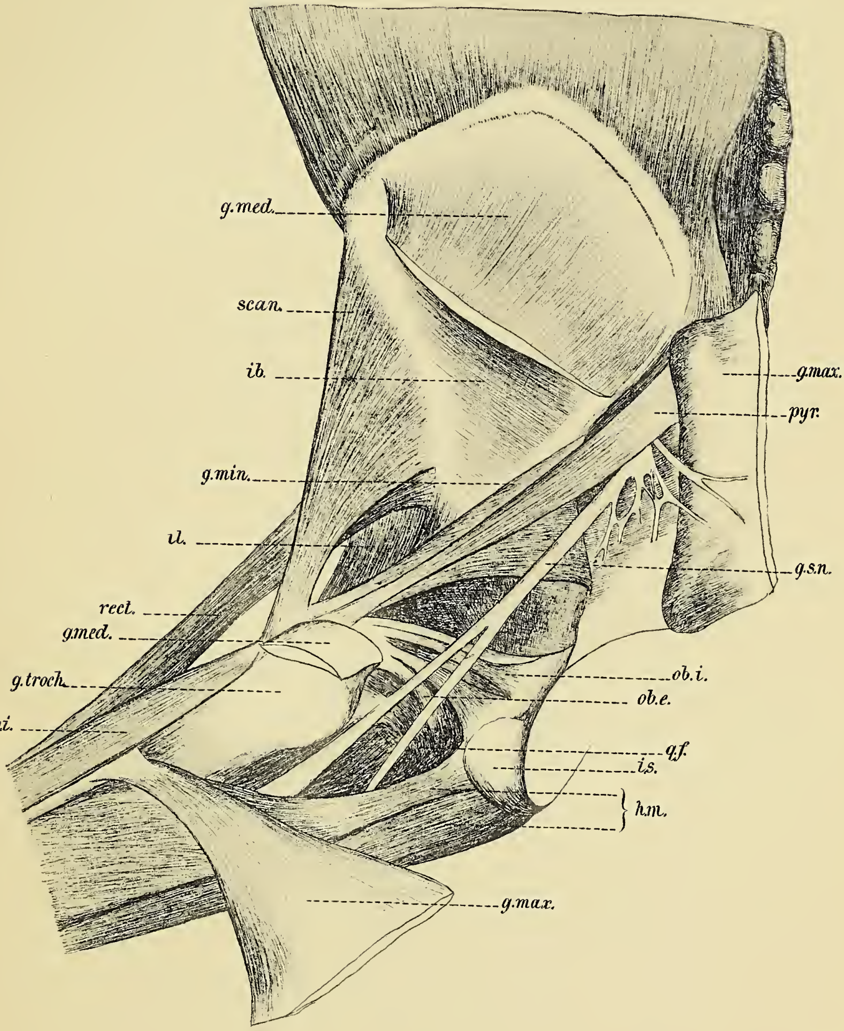

Fig.8.

Bensley, del.

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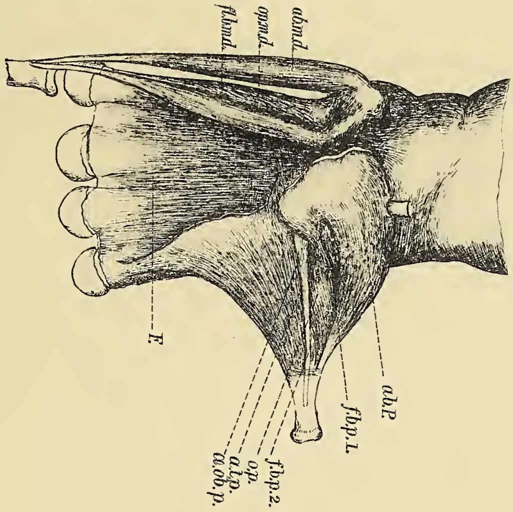
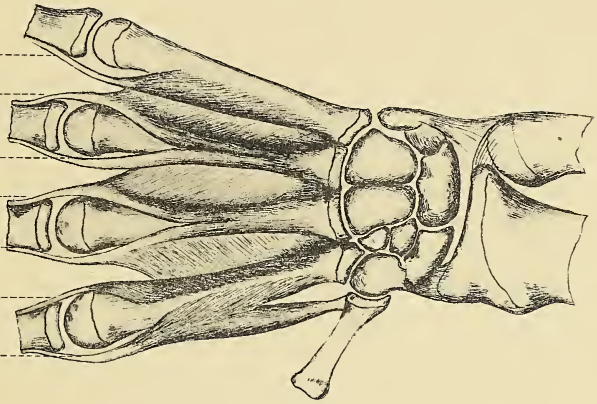


Fig. 5.



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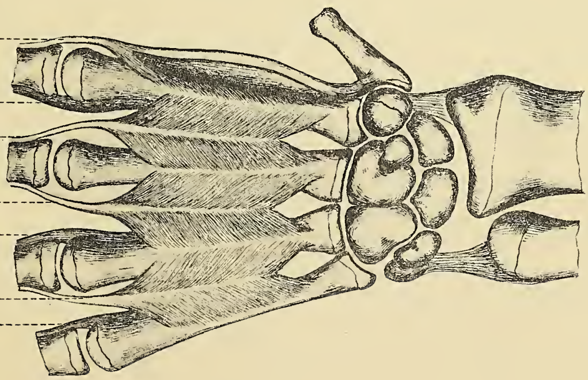

Fig. 7.

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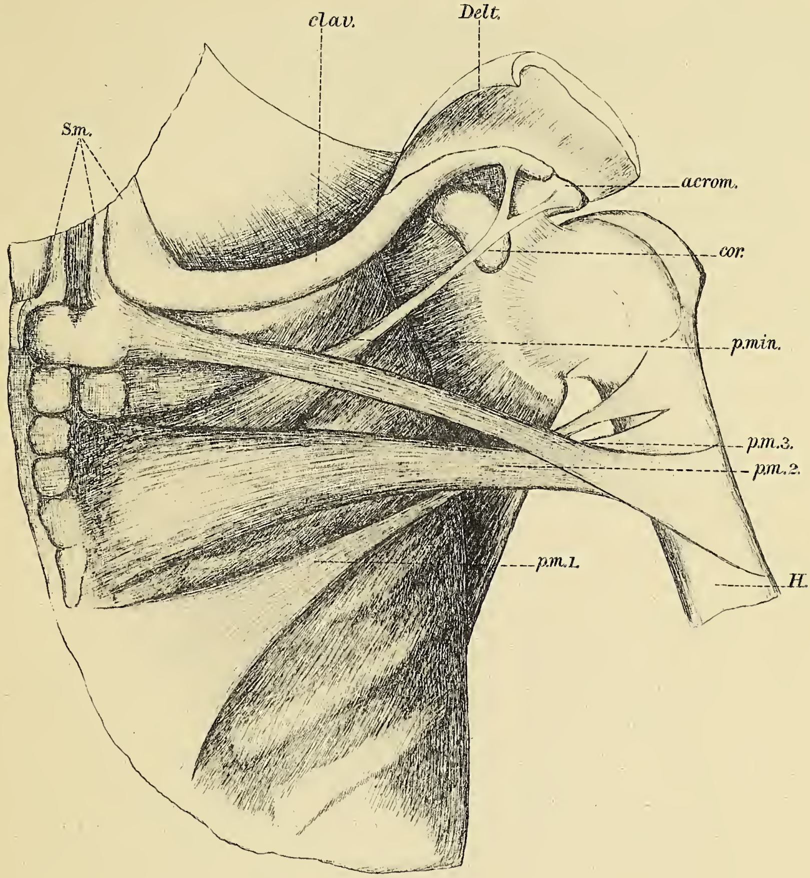

Fig. 2.

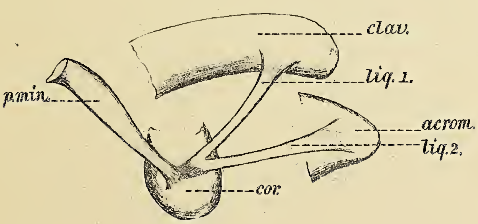

Fig. 3.

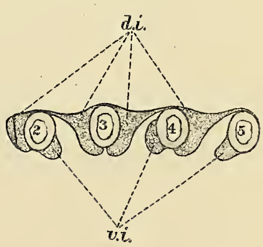

Fig. 4.

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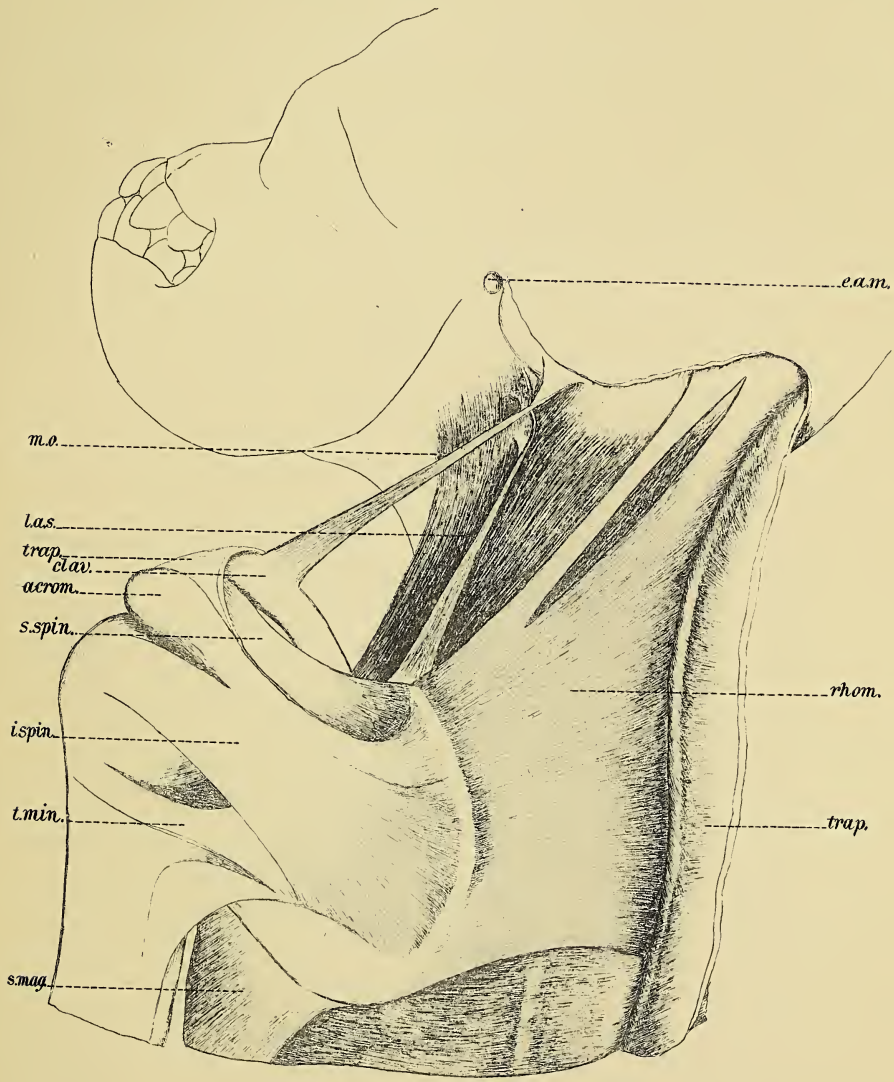

Fig.1.

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