

THE ANATOMY OF LOCOMOTION IN PRIMATES,
WITH PARTICULAR REFERENCE TO THE ORANG-UTAN.

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BY

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HISTORY:

The Ourang-utan, the Malay term meaning "wild man" or "man of the woods", has been the subject of scientific investigation for the past century and a half. In the early days many species of Orang were described from different localities of Borneo and Sumatra, but later it was realized that they all belonged to the same species, each forming a separate variety characteristic of that locality.

Having created a good deal of interest in the later part of the eighteenth century and during the first half of the nineteenth century, the Orang suffered a fresh wave of intensive research after the publication of Charles Darwin's "Origin of Species" in 1859, and still more after his "Descent of Man" in 1874. Interest waxed highest during the last quarter of the nineteenth century, but now during the twentieth century it has steadily waned. This, no doubt, is a natural reaction to the accumulation of knowledge of this beast, there being a tendency to regard this animal as an open book, and as a branch of primate evolution too specialized to serve a useful purpose in explaining the development of the Evolutionary Tree. It is of interest to note here that very little is known of the ancestry of the Orang, few skeletal links of its line of evolution having ever been discovered.

OBJECTS OF STUDY:

It has been my good fortune to obtain an Ourang-utan, for purposes of study, through the generosity of Professor Raymond A. Dart.* The main object in view was to make a detailed investigation of the gross anatomy of the head and neck together with the upper and the lower limbs of the animal. After this had been completed, it was decided to compare the upper and lower limb

musculature of the Orang with the musculature of these limbs in the Macacus rhesus monkey and in Man. The object of this comparison was to elucidate the main differences in the anatomy of these muscle systems and to see if these differences had any relation to the habits and modes of progression of the various animals concerned.

Macacus rhesus was chosen as a typical member of a primitive and generalized arboreal type, the Orang being, in relation, a more highly evolved and specialized arboreal type, while Man is the highly evolved and specialized terrestrial biped. A study of the literature gave the impression that interest in the anatomy of the Orang had waned as soon as it was realised that his obvious anatomical specialisations debarred him from any place in the structural ancestry of Man. The proposed analysis was aimed at making these anatomical specialisations serve as a basis for significant comparisons and contrasts.

This work, therefore, falls naturally into two sections: the first being a description of the actual musculature of upper and lower limbs in this specimen of Orang, with comment on available literature; and the second being a discussion of the muscular systems of the upper and lower limbs in Orang, Rhesus monkey and Man, in relation to their various habits, postures and modes of progression.

MATERIALS:

a): For the first part: the Orang obtained for examination was a young female animal which had had the major portion of its skin removed before it came into my possession. The various measurements of this animal were:-

- 1): Length of Upper Limb (from Greater Tuberosity of humerus to tip of third finger) 38.2 cms
- 2): Length of Arm (from Greater Tuberosity to Olecranon) 11.7 cms

- 3): Length of Forearm (Olecranon to middle of the
extensor surface of wrist-joint) 13.5 cms
- 4): Length of Hand (from middle of wrist to tip
of third finger) 13.0 cms
- 5): Length of Lower Limb (Greater Trochanter to
back of Calcaneum) 19.5 cms
- 6): Length of Thigh (Greater Trochanter to lateral
part of Knee Joint) 11.3 cms
- 7): Length of Leg (from medial part of Knee Joint
to medial malleolus) 8.5 cms
- 8): Length of Foot (from back of Calcaneum to tip
of fourth toe) 14.3 cms

b): For the second part of the work my own findings on the Orang, slightly modified, in certain instances, by the literature when my animal varied a great deal from the average, were used for purposes of comparison. The muscles of the Macacus rhesus were taken from the book on this animal - "The Anatomy of the Rhesus Monkey", written by Hartman and Straus. Cunningham's "Text Book of Anatomy" served as the standard for the Human musculature.

* I have since been informed by Prof. Raymond A. Dart that his Orang-ultra was sent to him from Borneo by Prof. J. Shillshar in 1925.

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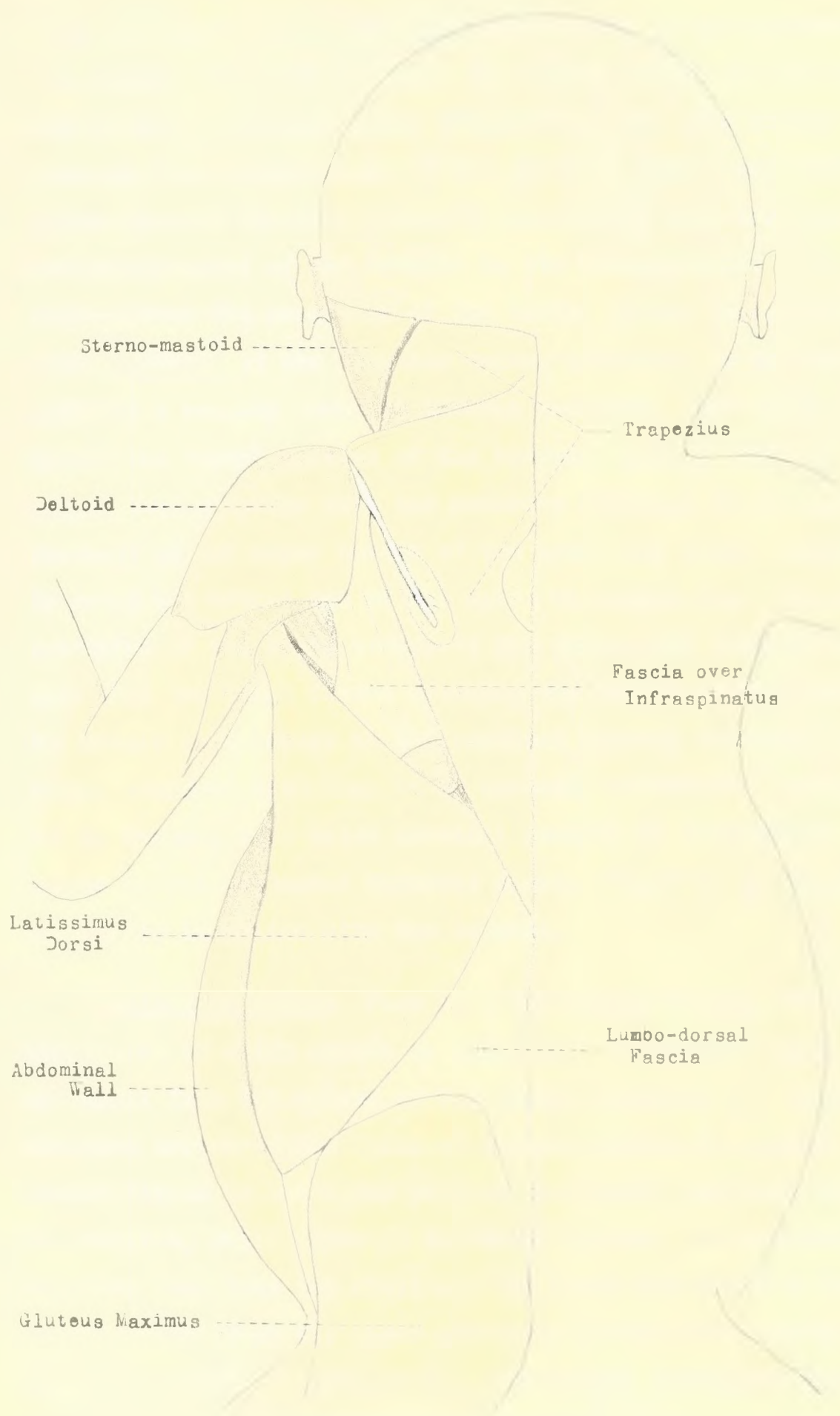
PART ONE

MUSCLES OF THE UPPER LIMB

MUSCLES CONNECTING UPPER LIMB TO TRUNK

TRAPEZIUS: This muscle was found to arise by fleshy fibres (1) from the medial one-third of the Superior Nuchal line of the occipital bone; (2) from the whole length of a median fibrous septum (which represents the Ligamentum Nuchae in Man); (3) from the spines of the 6th and 7th cervical vertebrae, and (4) from the spines and supraspinous ligaments of all 12 thoracic vertebrae. The origin below T.9 was by a fibrous sheet which overlies and attaches to the uppermost part of the Latissimus Dorsi muscle near the midline. The origin from C.7 and T.1 was mostly fibrous, it forming a small triangular fibrous area at this level with its apex pointing laterally (see Fig. 1). Sullivan and Osgood, and Sonntag found the occipital origin to include the medial half of the superior nuchal line, while Hepburn found the occipital origin extending as far outwards as the mastoid process. Sonntag mentions that the dorsal origin includes only the upper 7 thoracic spines, while Sullivan and Osgood find the origin extending as far downwards as the first lumbar spine. The latter likewise mention the fusion of the caudal end of this muscle with the cephalic end of the latissimus dorsi which it overlies. All the workers mentioned above deny the existence of an aponeurotic area over the lower cervical and upper thoracic spine, - a feature, according to Sullivan and Osgood, characteristic only of the human muscle.

The fibres arising from the occiput and from the upper three-quarters of the median cervical septum run downwards and laterally, coming to lie partially in front of the shoulder, and insert



into the upper surface and posterior border of the clavicle in its lateral one-third and into the medial border of the acromion and acromio-clavicular joint (Figures 4 & 5). The fibres arising from the lower one-quarter of the cervical septum and from C.6.7. T.1.2. proceed directly laterally and insert into the upper border of the spine of the Scapula in its lateral half. The fibres arising from the remainder of the muscle origin sweep towards the medial portion of the scapular spine, attaching to the circumference of a roughly circular fibrous membrane, into which is imbedded the medial portion of the Scapular spine. This is arranged in such a manner that the membrane attaches to the medial one-half of the upper border of the spine and swoops continuously round the medial end of the spine to attach along the medial one-third of the lower border of the spine, and becomes continuous with the rough fascia covering the infraspinatus muscle. The muscle is thickest in the cervical region, although, as a whole, compared with Man, it is markedly thickened. As pointed out by Sommer, this thick cervical portion is assisted in its action by the subjacent rhomboid sheet. There is no fusion of the muscle insertion with the Deltoid.

LATISSIMUS DORSI: This is a fan-shaped muscle, the upper two-thirds of which arises by means of a tough triangular sheet^t of fascia from the spines of the tenth, eleventh and twelfth^f thoracic vertebrae and those of all the lumbar vertebrae. The muscle fibres of the upper part of the muscle approach closest the midline, while those of the lower portion of the muscle are furthest away from the midline. The lower one-third of the muscle arises from the upper and outer border of the whole of the iliac crest (See Figure 1). The muscle converges upwards and laterally towards the axilla (see Figure 1). No costal or scapular attachments were found.

Sonntag found this muscle to have its origin extending as far cranially as the spine of the eighth thoracic vertebra. Osgood and Sullivan state that the aponeurotic origin extended from the spines in the midline on to the medial third of the iliac crest. Sonntag describes additional origins from the outer surfaces of ribs 6-11, but this finding is not mentioned by other workers. The scapular origin is found constantly lacking in all great apes and this differs from the human muscle.

The upper part of the muscle partially covers the *Terres Major* and passes laterally round it (Figure 7). The insertion is by two distinct and separate ribbonlike tendons into the floor of the bicipital groove of the humerus. The upper half of the muscle gives rise to the lower of the two tendons, inserting into the floor of the bicipital groove at the level of the lower border of *Terres Major* insertion and downwards for 1 mm. or more. The converging fibres of the lower half of the muscle pass first laterally, then inferiorly, and finally anteriorly to the converging fibres of the upper half, there being a spiral twist so that the anterior surface of the upper ribbonlike tendon is continuous with the posterior surface of the lower half of the muscle. This upper tendon is considerably larger than the lower one, and it inserts into the floor of the bicipital groove at the level of the upper border of the insertion of *Terres Major*. The lower half of the muscle is thicker than the upper half. Sullivan and Osgood find a similar method of insertion, the only difference being that the muscle is divided into two unequal parts - the upper one-quarter giving rise to the lower tendon and the lower three-quarters giving rise to the upper tendon. Sonntag, however, makes no inference that the muscle in his orang is inserted by anything but a single tendon.



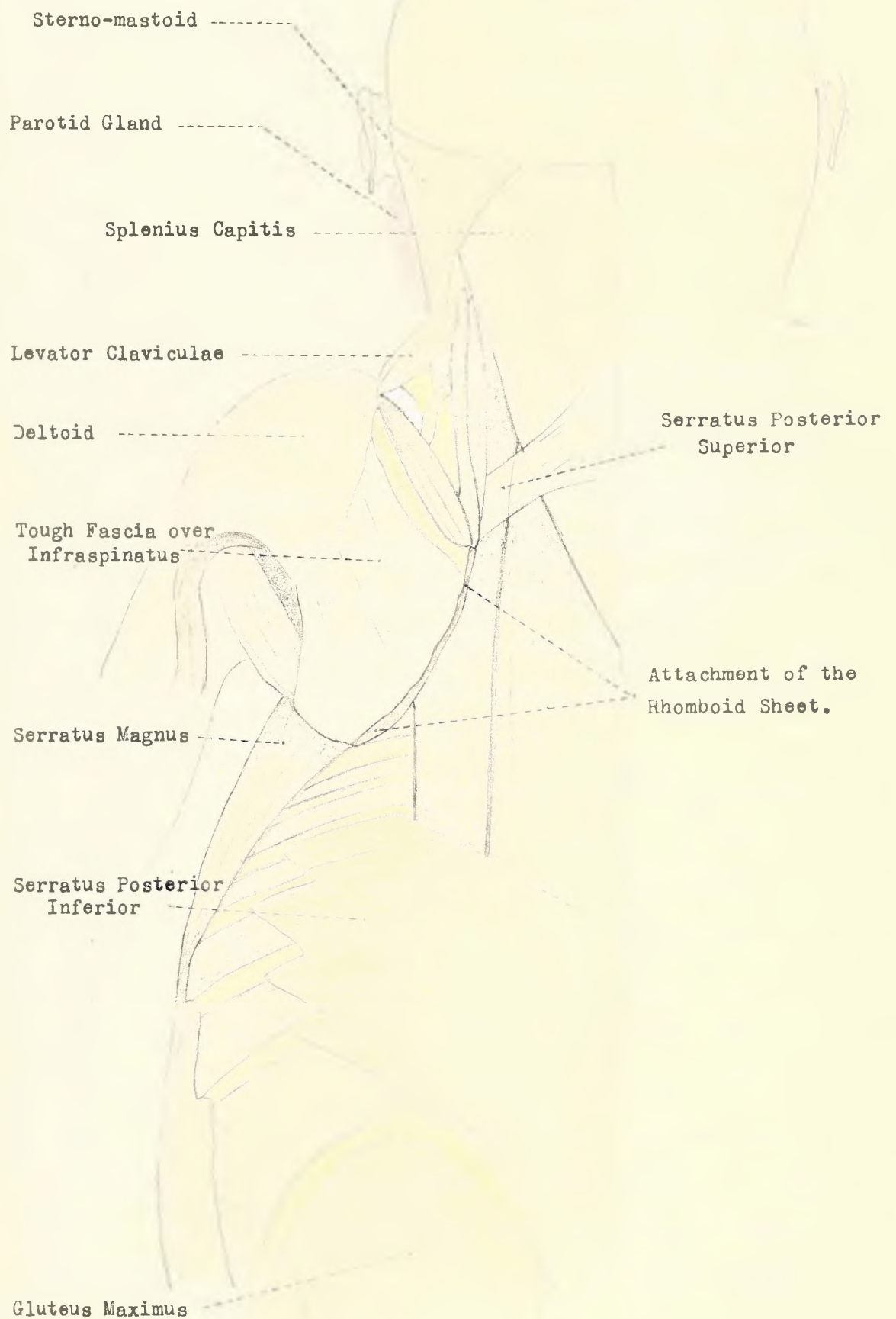
RHOMBOIDEUS: This was found as a large single sheet of muscle which showed no division into major and minor portions. It took origin (1) from the superior nuchal line in its medial one-quarter deep to the origin of the Trapezius; (2) from the whole length of the median fibrous septum of the cervical region (i.e. the ligamentum nuchae); and (3) from the spines of C,6,7. T.1,2,3,4,5. and from supra-spinous ligaments. The lower border of the muscle has a more or less separate slip arising from the supraspinous ligament between T.5 and 6 (Figure 2).

Sullivan and Osgood and Sonntag found that part of the muscle arising from the occipital bone as a separate slip, the former workers calling it the "Omo-occipitalis", while Sonntag calls it the "Rhomboides capitis". Fick found no occipital origin in the muscle group, while Beddard describes major, minor and occipital rhomboids.

The upper fibres run downwards and slightly laterally, while the lower fibres run laterally and slightly downwards, the insertion being into the whole length of the vertebral border of the Scapula, from the upper angle to the lower angle. Sullivan and Osgood find the insertion falling a little short from both angles of the Scapula.

LEVATOR CLAVICULAE: The muscle arises from the lateral portion of the transverse process of the Atlas. It passes laterally and downwards as a stout column of muscle, crossing the sterno-mastoid posteriorly and lying anterior to the Levator Scapulae muscles. It inserts into the inner or posterior border of the lateral one-quarter of the clavicle.

Sullivan and Osgood have named the muscle the "Omo-cervicalis". They find the insertion is into the clavicle, lateral to its middle. They state that the clavicular attachment seems



fairly constant for the anthropoids, but that in other primates it may pass to the acromion or spine of the scapula. Sonntag gives the insertion as being into the acromion.

ATLANTO-SCAPULAE: This small muscle arises from the lateral portion of the transverse process of the Atlas, posterior to the origin of Levator Clavicularae. It passes downwards and backwards as a thin flat column of muscle which inserts into the upper border of the superior angle of the Scapulae (Figures 2,3). It rests in its whole extent on the superior border of the Levator Scapulae muscle. It is not mentioned by Sonntag or by Sullivan and Osgood; who, no doubt, have included it as part of the Levator Scapulae muscle.

LEVATOR SCAPULAE: The origin was by fleshy slips from the transverse processes of the upper four cervical vertebrae, that from the Atlas being posterior and deep to the origin of the ^tAtlanto-Scapulae muscle. It inserts into the costal edge of the superior angle of the scapula, the muscle being a single undivided sheet (Figure 2,3).

Sullivan and Osgood report this muscle as consisting of four quite distinct slips. Their origin is by five small tendons from the transverse processes of the upper four cervical vertebrae, two slips coming from the third. The segments from the several vertebrae remain independent throughout the entire length of the muscle, but the two slips from the third soon fuse to form a single bundle. Sonntag maintains that the slips of origin do not remain separate, but fuse to form a single sheet of muscle. Various authors have given origins even as far down as the seventh cervical spine. The muscle has been described as fusing with the serratus anterior - as

in many marsupials. The levator scapulae has been described as the *caput Colli*.

MUSCLES OF THE PECTORAL REGION

PECTORALIS MAJOR: This muscle was found to be in three distinct and completely separate portions. upper, middle and lower portions (Figure 4). The upper portion took origin by two heads. The larger superior head arises from the anterior surface of the upper half of the manubrium sterni on its respective side. The smaller inferior head arises from the lateral border of the anterior surface of the manubrium, from adjacent areas, and from the medial portion of the second costal cartilage. This muscle bundle merges with the fibres of the inferior surface of the superior head. The whole now extends laterally as a round stout column of muscle which tends to flatten out as it approaches its insertion into the lateral lip of the bicipital groove of the humerus, extending from the capsule of the shoulder-joint above to the insertion of the Deltoid muscle below. It lies superficial to the inserting portion of the pectoralis minor muscle.

The middle portion of the Pectoralis major is by far the largest portion. It has a fleshy origin from the anterior surface of the lower portion of the sternum, from the third, fourth, fifth and sixth costal cartilages, and from the tough fascia overlying the oblique and rectus muscles near the midline. The muscle converges upwards and laterally giving rise to a small fibro-muscular insertion into the lateral lip of the bicipital groove, being deep to the insertion of the upper portion. The middle of this portion overlies the pectoralis minor muscle.

The lower portion is the smallest of the three. It arises from the fourth and fifth ribs over and lateral to the costo-

Orbicularis Oculi

Mouth

Platysma

Trapezius

Deltoid

Clavicle

Delto-pectoral
triangle

Pect. Minor

Axilla

Second Portion of
Pectoralis Major

Abdominal Portion of
Pectoralis Major

Epitrochlearis

Figure 1. Anterior view of the human torso showing the muscles of the neck and upper chest.

chondral junction. Its more superficial fibres arise from the tough fascia over the external abdominal oblique muscle. It converges in an upwards and slightly lateral direction to insert by a thin flat tendon into the uppermost portion of the lateral lip of the bicipital groove - deep to the insertions of the other two portions, and higher up the humerus than the insertion of the middle portion. This lower portion runs almost parallel to the Pectoralis Minor, and looks like it, being only more anterior and more lateral than this muscle. The clavicle was entirely free from the Pectoralis Major muscle.

Sonntag, who also finds the origin in three distinct parts, finds that the upper part takes origin from the innermost portion of the clavicle as well as its origin from the manubrium - and accordingly calls this the clavicular head. His lower portion evidently gains no origin from the ribs, but arises solely from the fascia over the external abdominal oblique muscle. The three parts fuse to form a combined muscle which then goes to its insertion by a single tendon. Sullivan and Osgeod describe the pectoralis major to be in three distinct segments, a manubrial, a sterno-chondral, and a costo-abdominal. They mention that the clavicular head is wanting and state that this is usually the case. Their sterno-chondral portion has its origin extending right down to the seventh costal cartilage, and their costo-abdominal portion also seems to have its costal origin moved more distally, since it arises from the fifth and sixth ribs, besides the origin from the external oblique aponeurosis. Hepburn states that no clavicular origin for Pectoralis Major was found, and this is confirmed by the findings of Biscoff and of Sandifort. Flick reports that the three portions of the muscle remain entirely separated, while Seddard mentions that two parts unite before their insertion.

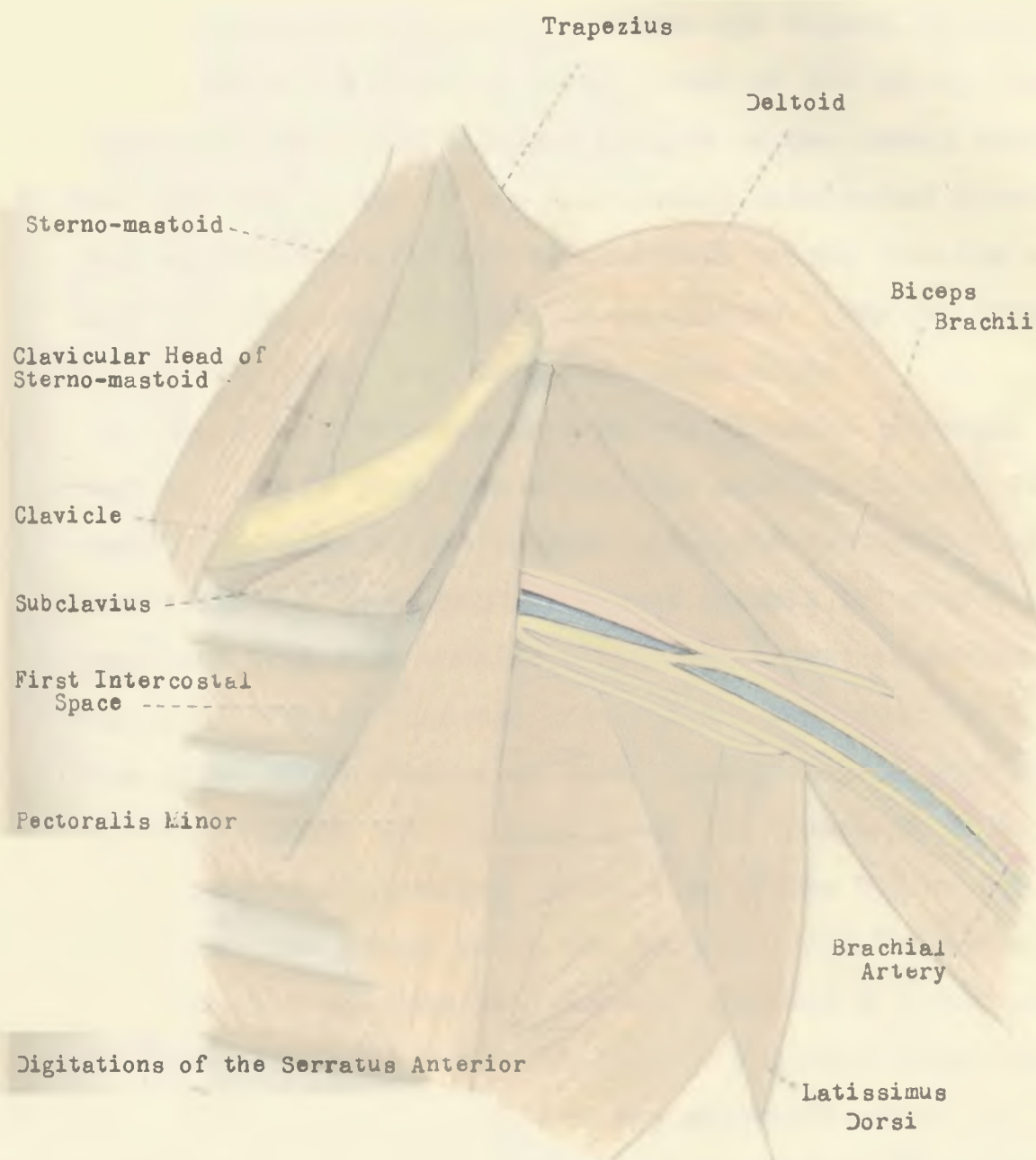


FIG. 15. DEEPER LAYER OF THE PECTORAL REGION, PECT. MAJOR REMOVED.

PECTORALIS MINOR: The muscle was found to arise (1) from the third and fourth ribs, and (2) from the rough fascia overlying the second and third intercostal spaces (Figures 4,5). The origin, as described by Sullivan and Osgood, is more extensive since it is from the ventral ends of the third, fourth and fifth ribs, from the adjacent portion of the costal cartilages, and from the fascia of the intervening intercostal muscles. Sonntag reports still a more extensive origin from the second, third, fourth and fifth costal cartilages. Hepburn found the origin only from the third and fourth ribs.

The fibres converge upwards and slightly laterally to insert by a small flat tendon into the anterior surface of the coracoid process of the Scapula medial to the origins of Coraco-Brachialis and Short head of Biceps Brachii (Figure 7). Primrose found the insertion continuous with the trapezoid portion of the coraco-clavicular ligament and with the coraco-acromial ligament. Fick gives the insertion as being into the upper surface of the coracoid process and Bischoff gives its insertion as the root of this coracoid process. Beddard describes the muscle as consisting of two parts, which are inserted into the coracoid process and into the humerus. Sonntag observed a double muscle in a Chimpanzee, while Duckworth figures a double muscle in the Gorilla, so it is evident that the pectoralis minor may be met with as a single or a double muscle in each of the higher Simiidae.

SUBCLAVIUS: This small slender muscle took origin by fibro-muscular tissue from the first costal cartilage just lateral to the sterno-clavicular joint and just medial to the costo-chondral junction. Fibres pass laterally and upwards to attach to the inferior surface of the lateral third quarter of the clavicle. (Figure 5).

SERRATUS ANTERIOR: This large muscle was found to arise by fleshy digitations from the lateral surface of ribs 1 - 10. The portion of the muscle arising from the first rib is very much thicker and heavier than those digitations arising from the other ribs. and its fibres travel laterally and backwards to insert into the vertebral border of the Scapula on its costal surface in about its upper three-quarters (Figures 2,3,5). The slips from ribs 5-9 interdigitate with the origin of the External Abdominal Oblique muscle. The rest of the muscle finds insertion into the costal surface of the lower one-quarter of the vertebral border of the Scapula. The lower part of the muscle is decidedly thicker than the intermediate part.

Sullivan and Cagood find the origin extending one rib further distally - to the eleventh rib, and they state that that portion of the muscle from the fifth rib to the eleventh rib, ~~and they state~~ interdigitat^tes with the external abdominal oblique. They mention that this muscle is rarely found to be continuous with the levator scapulae muscle. Sonntag describes the Serratus anterior as being in two distinct parts, the proximal, greatly thickened part arising by three digitations from the upper three ribs, while the distal part arises from ribs 5-10 inclusive, by six digitations, thus leaving the fourth rib free from any origin of this muscle.

MUSCLES OF THE SHOULDER

DELTOID: The muscle had origin from the anterior surface of the lateral half of the clavicle (Figures 4,5,7), from the lateral surface of the acromion process, from the lower border of the lateral half of the spine of the scapula, and then by means of a fibrous sheet, from the remainder of the spine of the scapula and from the dense fascia over the Infraspinatus muscle. (Figures 1,2,3).

Coracoid Process

Acromial Process

Infraspinatus

Teres Minor

Deltoid Tuberosity

Lateral Head of Triceps

Brachialis

Supraspinatus

Spine of the
Scapula

Teres Major

Long Head of Triceps

The fibres pass laterally, forming a thick covering over the shoulder joint, to insert into the "deltoid tuberosity" on the lateral surface of the upper second quarter of the shaft of the humerus. The muscle forms one indivisible whole of approximately uniform thickness, two-thirds of it being posterior to the plane of the acromio-clavicular joint.

Sullivan and Osgood describe the muscle as being in three parts - a ventral fourth (clavicular), a middle two-fourths (acromial and spinous), and a dorsal fourth (spinous and infraspinous). Sonntag states that the muscle is not divided into parts. Mivart notes that there is usually no deltoid tubercle.

SUPRASPINATUS: This muscle arises by fleshy fibres from the superior surface of the spine of the scapula and from the whole of the supraspinous fossa (Figures 2,3,6,7,8). It passes laterally as a thick belly of muscle, passing deep to the acromion process and coraco-acromial ligament. It inserts by a flat ^tendon into the superior surface of the greater tuberosity of the humerus and into the capsule of the shoulder joint, being superior and anterior to the insertion of the Infraspinatus muscle. Sullivan and Osgood mention that the muscle has but a very loose attachment to the capsule of the shoulder joint.

INFRASPINATUS: The origin of this muscle was from the triangular infraspinatus fossa of the scapula, from the inferior surface of the spine of the scapula, and from the very dense infraspinatus fascia covering the muscle (Figures 1,2,6,7). The muscle fibres converge laterally and give rise to a stout flat tendon which inserts into the postero-superior surface of the greater tuberosity of the humerus, just above the insertion of Teres minor, and into the capsule of the shoulder joint.

This muscle, like the Supraspinatus above, appears to be a very constant muscle, since all the literature agrees closely on it.

131/33 INER: This muscle was found to have origin from the lateral half of the outer surface of the axillary border of the Scapula, and also to a certain extent from the posterior surface of the broad tendon of origin of the long head of triceps (Figure 6). Sonntag found the muscle to arise from a little more than the lateral half of the axillary border of the scapula, while Sullivan and Os good maintain that the muscle arises from the upper two-thirds of the axillary margin of the scapula. None of these workers mention an origin from the dorsum of the tendon of origin of the long head of triceps.

The muscle flattens out as it passes laterally, inserting by fleshy and tendinous fibres into the posterior aspect of the greater tuberosity of the humerus, just inferior to the insertion of the Infraspinatus muscle, and also into the posterior surface of the capsule of the shoulder joint.

131/33 MAJOR: The origin of the muscle is from the medial half of the axillary margin of the scapula, the muscle fibres encroaching to some extent onto the dorsal surface of the scapula right down to the inferior angle (Figures 6,7). Sonntag, as well as Sullivan and Os good, found the muscle to arise only from the inferior third of the axillary margin and the adjacent part of the dorsal surface of the scapula.

The muscle passes laterally as a very stout little belly deep to the long head of triceps, and, flattening out into a wide thin tendon, it inserts into the medial lip of the bicipital groove of the humerus (Figure 1,2,6). Sonntag states that the origin is fused with the subscapularis and its insertion is

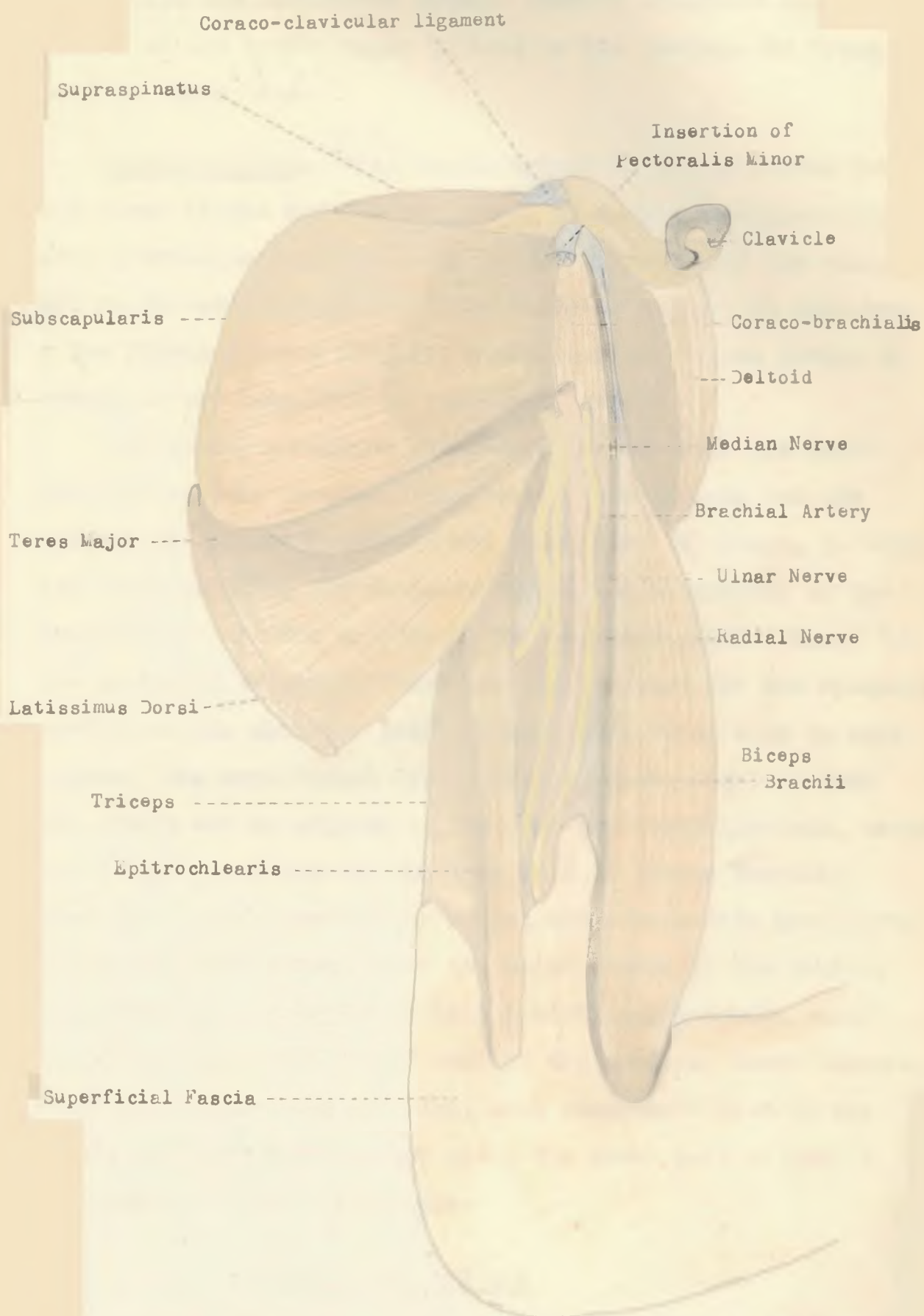


FIGURE 7. MEDIAL ASPECT OF SCAPULAR AND HUMERAL REGIONS

fused with the latissimus dorsi. Hepburn indicates that the origin of the *teres major* is less in the Gorilla and Orang than in other Apes.

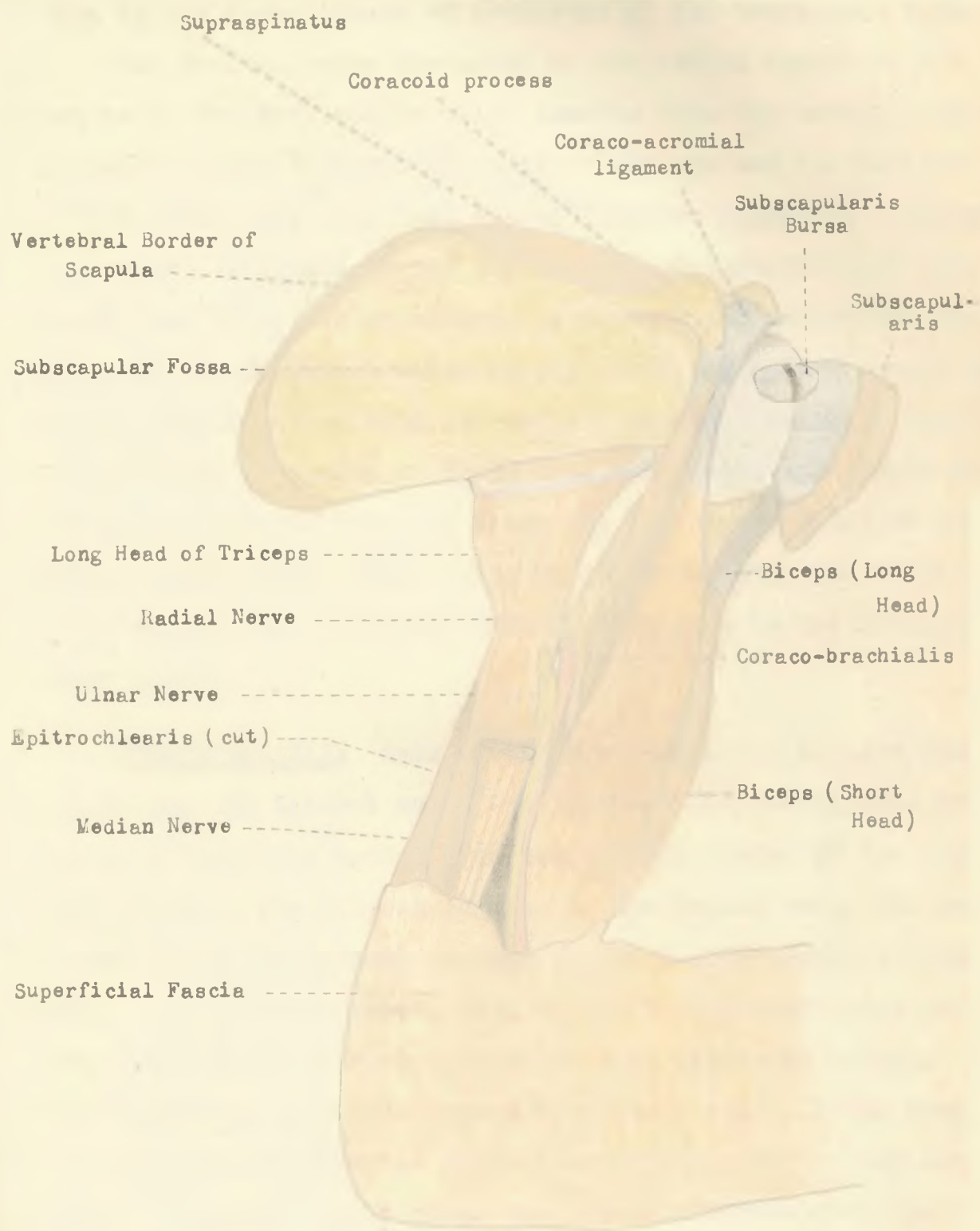
SUBSCAPULARIS: This muscle arises by fleshy fibres from the whole of the subscapular fossa, it having a particularly strong attachment to the lower vertebral border of the Scapula and to the costal surface of its inferior angle. It also has a few fibres arising from the costal surface of the tendon of origin of the long head of *triceps* (Figure 7).

The muscle converges laterally, passes under the overhanging Coracoid process, then between the scapula and the origins of *Coraco-Brachialis* and short head of *biceps*, to reach its insertion into the whole of the lesser tuberosity of the humerus and into the capsule of the shoulder joint (Figure 8). The tendon of insertion forms the true support for the anterior portion of the shoulder joint, the capsule being thin in this region. The superficial fibres of the tendon continue over the groove and so helping to form the transverse ligament, under which lies the tendon of the long head of *biceps brachii*. There is a small subscapular bursa, continuous with the cavity of the shoulder joint, under the upper border of the tendon.

Sullivan and Osgood mention a small upper bundle which is quite independent of the rest of the muscle. These workers, together with Bonntag and Flick, have observed fusion of the muscle with the *teres major* along the lower part of the axillary margin of the scapula.

MUSCLES OF THE ARM

DORSO-EPITRACHEALIS: The origin was found to be from the upper tendon of insertion of the *Latissimus Dorsi* (i.e. that tendon arising from the lower half of the muscle) just where

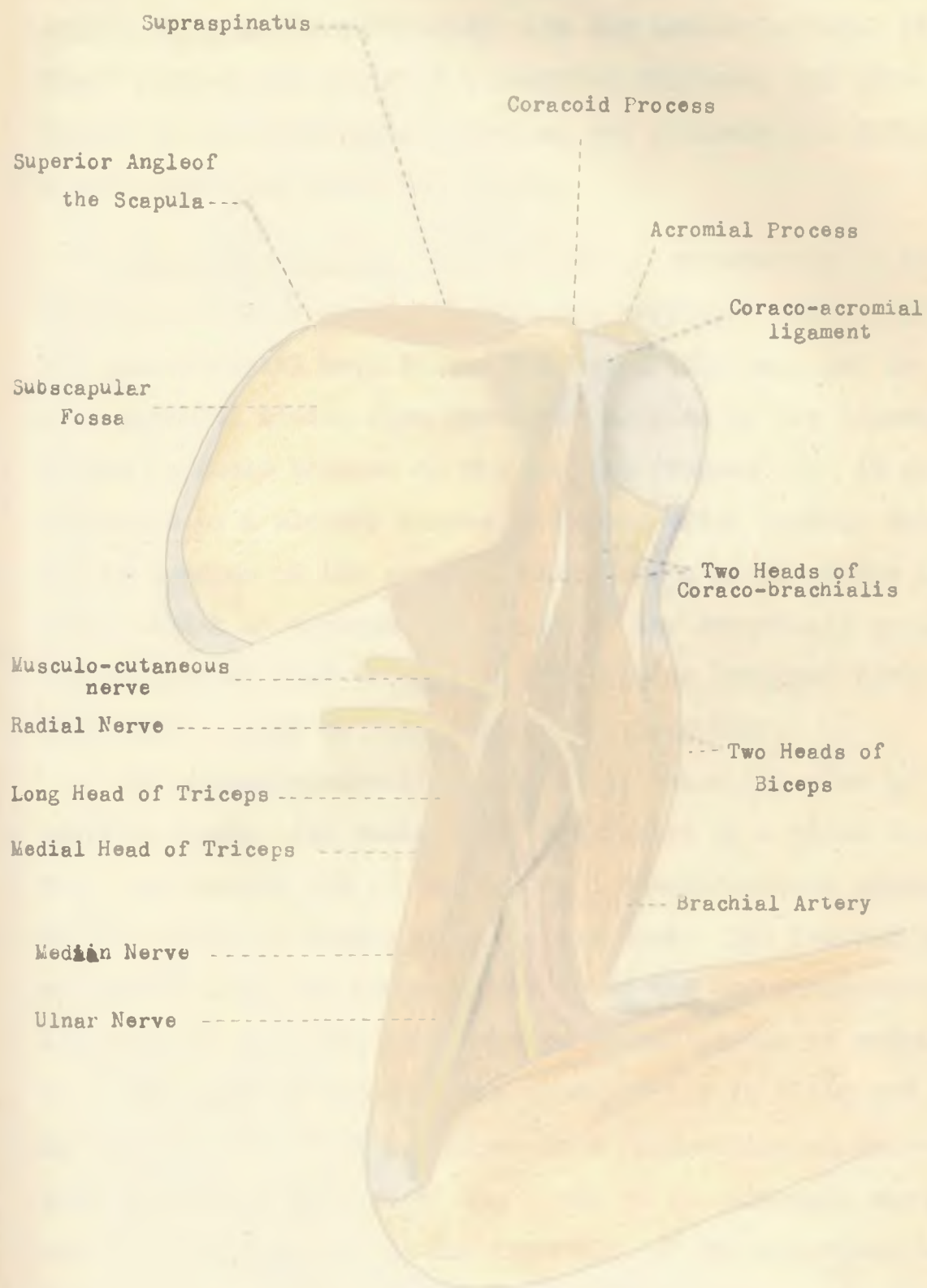


the muscle fibres give rise to the tendon. It had no attachment to the lower tendon of insertion of the Latissimus Dorsi.

The muscle passes downwards on the medial aspect of the arm as a thin flat column which inserts into the Medial Intermuscular Septum in the lower half of the arm and its terminal fibres insert into the deep fascia (Figures 1,4,7,8). Sullivan and Osgood call this muscle the "latissimo-condyloideus" and state that it may be considered as part of the latissimus dorsi although its different nerve supply (from the radial nerve) probably indicates that this is really a separate muscle. They describe the insertion as being into the medial epicondyle of the humerus and to the line above it, the distal third of the muscle being aponeurotic. Hepburn comments that this muscle never reaches the medial epicondyle, but ends in the intermuscular septum.

BICEPS BRACHII: This muscle was completely divided into two heads, the lateral being the larger. The Medial head arises by a flat thin tendon from the lateral border of the Coracoid Process, the lateral portion of the tendon being the continuation of the lateral portion of the Coraco-acromial ligament. The postero-lateral head of the Coraco-brachialis partly originates from the deep surface of this tendon of origin. The Lateral or Long head arises by a long, rough, round tendon which originates from the Supraglenoid tuberosity of the Scapula and from the upper part of the Labrum Glenoidale of the shoulder joint.

The two bellies do not fuse until just before their insertion into the Bicipital Tuberosity on the medial surface of the radius, the fibres from the medial or short head being here most anterior. A few fibres of the short head insert into the dense deep fascia over the medial portion of the cubital fossa,



Two Tendons of the
Extensor Indicis

Tendon of the
Extensor Pollicis Longus

Extensor Indicis

Radius

Ulna

Extensor Pollicis
Longus

Abductor Pollicis
Longus

Supinator

Brachialis

Lateral Supra-
condylar Ridge of
Humerus

Anconeus

but no distinct Lacertus Fibrosus could be made out (Figures 5, 7, 8, 9). Sullivan and Osgood do not describe such a powerful origin which is in continuity with the coraco-acromial ligament. These workers did not find a lacertus fibrosus, and this is confirmed by the findings of Sonntag, but Primrose has described a well-developed bicipital fascia.

CORACO-BRACHIALIS: This muscle is represented by two bellies, entirely separable from one another. (Figure 9). The antero-medial head is the smaller of the two, and it arises by a powerful tendon from the lower surface of the lateral tip of the Coracoid Process of the Scapula (Figure 8). It passes downwards as a slender column of muscle which inserts into the medial surface of the shaft of the humerus at about its middle, being wedged in between the origin of the Brachialis anteriorly and the medial head of Triceps posteriorly (Figures 7, 9). This muscle belly is thickest in its upper half.

The postero-lateral head is about twice the size of the previous head. Its medial half originates by a stout tendon from the lateral tip of the Coracoid Process, being posterior to the tendon of origin of the above head. Its lateral half originates from the lateral portion of the Coraco-acromial ligament and from the deep surface of the tendon of origin of the Short Head of Biceps. The muscle belly is thick and flat in its upper half and converges to a fibro-muscular insertion into the medial surface of the shaft of the humerus, superior and slightly anterior to the insertion of the antero-medial head. The Musculo-Cutaneous nerve passes between the two heads just above their insertions. Similar finding to the above have been made by Sullivan and Osgood, Sonntag, Church and Hepburn.

BRACHIALIS: This muscle was found to arise from the anterior surface of the lower half of the humerus, its medial fibres arising from the medial intermuscular septum and medial supracondylar ridge, its lateral fibres arising from the lateral surface of the shaft of the humerus in its middle one-third, and also from the anterior surface of the lateral supracondylar ridge (Figures 9,10,11). Where the Deltoid insertion and Brachialis origin become adjacent, it is seen that their fibres intermingle somewhat - a finding also described by Sullivan and Osgood. The muscle proceeds downwards, the lateral fibres running slightly medialwards and in a somewhat spiral fashion (Figure 12), and comes to insert into the coronoid process of the ulna. This insertion is large and very powerful, being in the form of an elongated triangle whose base is towards the elbow joint, and occupying fully one-sixth of the total length of the ulna (Figures 13,14,15).

Sullivan and Osgood describe the muscle as covering the distal two-thirds of the ventral surface of the humerus distal to the attachment of the deltoid. They state that the distal end of this muscle would seem to consist of three parts - a central part made up of long bundles from the middle third of the humerus, a medial segment consisting of slightly shorter bundles from the epicondylar line and shaft of the humerus, and a lateral portion made up of still shorter bundles coming from the lateral epicondylar line. The demarcation between the three parts is not sharp, but the central part goes over largely into a tendon at its distal end, whereas the lateral and medial remain fleshy.

Sonntag describes a different arrangement. He found the muscle to consist of two parts which only come together in the distal half. The inner part is described as arising from the

median half of the front of the front of the humerus, up to a point about a sixth of an inch above the lowest point of the deltoid insertion; and it is fused with the coraco-brachialis. The outer part arises from the lateral half of the front of the humerus and extends well above the insertion of the deltoid. The two parts are separated by a fissure in the upper part of their course. Distally they unite.

TRICEPS: The muscle has three distinct heads; the Long, Medial and Lateral heads.

The Long head arises by a thin very wide tendon from the Infraglenoid tuberosity and from the lateral half of the axillary border of the Scapula. The fibres run downwards and join those of the two parts of the muscle. It is by far the largest head of the three (Figures 6,8,9).

The medial head arises by fleshy fibres from the postero-medial surface of the Shaft of the Humerus in almost its whole extent, except for the uppermost part (Figure 9).

The Lateral head arises by tendinous and fleshy fibres from the postero-lateral surface of the shaft of the humerus. Its upper fibres are in close relation to the insertion of the Deltoid. The origin extends superiorly as far as the attachment of the capsule of the shoulder joint (Figure 6).

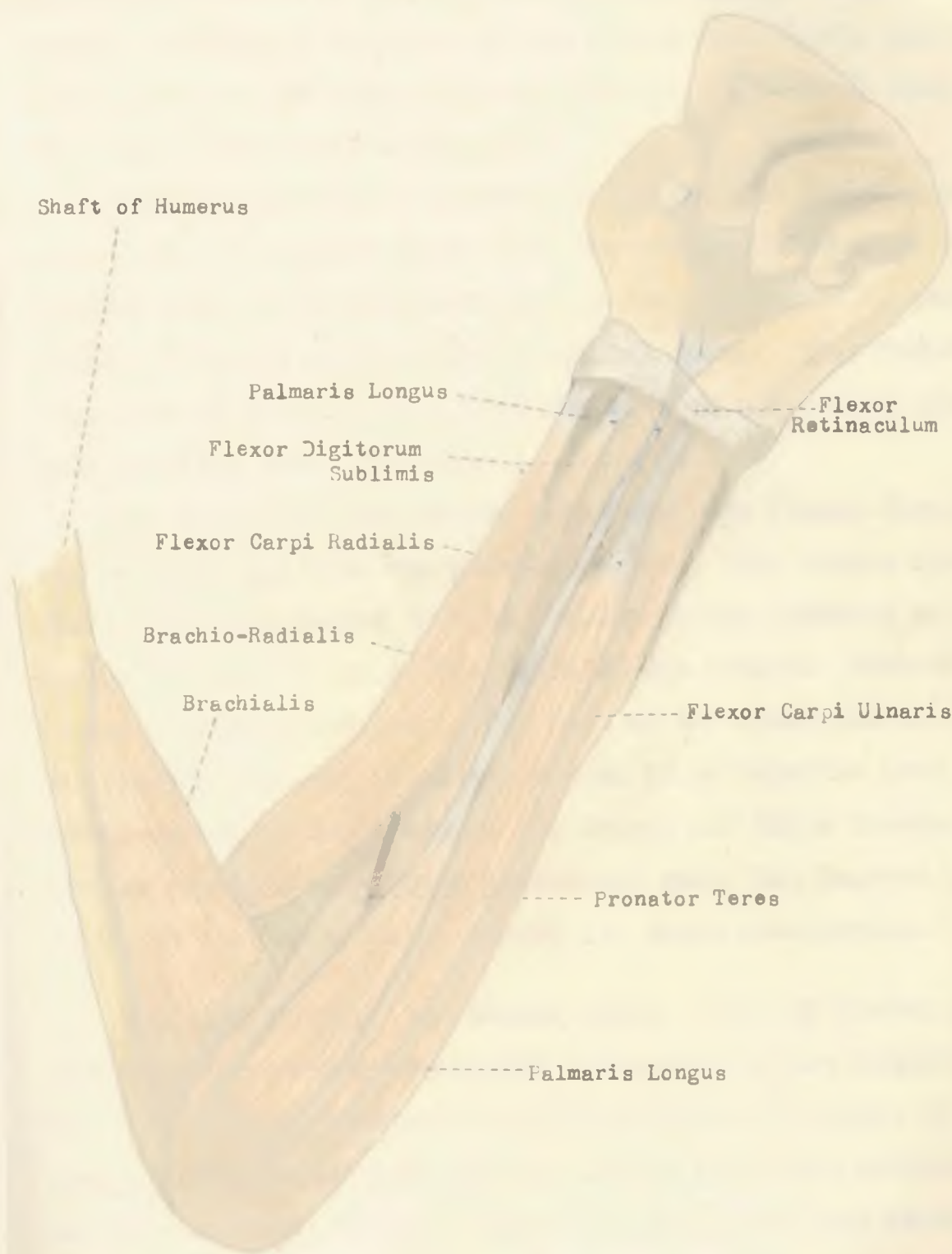
The long head fuses much sooner with the lateral head than with the medial head. The fused mass of the three heads gain further origin from the posterior surface of the lower half of the shaft of the humerus. The triceps inserts by a tendon into the tip and posterior surface of the Olecranon of the ulna. Thus the only real difference between this muscle in Orang and in Man is the Long head of origin. Sullivan and Osgood and Sonntag give descriptions of this muscle which correspond very closely to the above description.

MUSCLES OF THE FOREARM.

PRONATOR TERÆS: This comparatively powerful muscle arises by two heads. The superficial head takes origin by fleshy and tendinous fibres from the medial epicondyle of the humerus and from the lateral surface of the tendon of origin of the Flexor Carpi Radialis (Figures 10,11). The deep head is large and powerful, arising mostly by tendinous fibres from the coronoid process of the ulna in a diagonal manner, pointing distally and laterally, and being directly distal to the insertion of the Brachialis. This head forms the postero-lateral portion of the muscle which is largely tendinous. The median nerve passes between the two heads.

After passing downwards and laterally the muscle inserts by tendinous fibres into the lateral border of the shaft of the radius just proximal to its middle. The insertion, which is wide, is also long, it occupying one-quarter of the length of the radial shaft. Sonntag, Osgood and Sullivan give similar descriptions of this muscle. Hepburn points out that the muscle has no coronoid head in the Gorilla and Gibbon, Langer and Fick both describe long insertions in the Orang and give actual figures comparing it with Man.

FLEXOR CARPI RADIALIS: The muscle gains origin by tendinous fibres from the medial and anterior surface of the medial epicondyle of the humerus. The origin is by a thin wide tendon flattened between the medial portion of Pronator Teræ and the lateral surface of Flexor Digitorum Sublimis (Figures 10,11). The lateral portion of the muscle arises by tendinous fibres from the anterior surface of the shaft of the radius deep to the insertion of Pronator Teræ. The remaining intermediate portion of the muscle arises from a tough tendinous sheet, deep



Shaft of Humerus

Palmaris Longus

Flexor Digitorum
Sublimis

Flexor Carpi Radialis

Brachio-Radialis

Brachialis

Flexor
Retinaculum

Flexor Carpi Ulnaris

Pronator Teres

Palmaris Longus

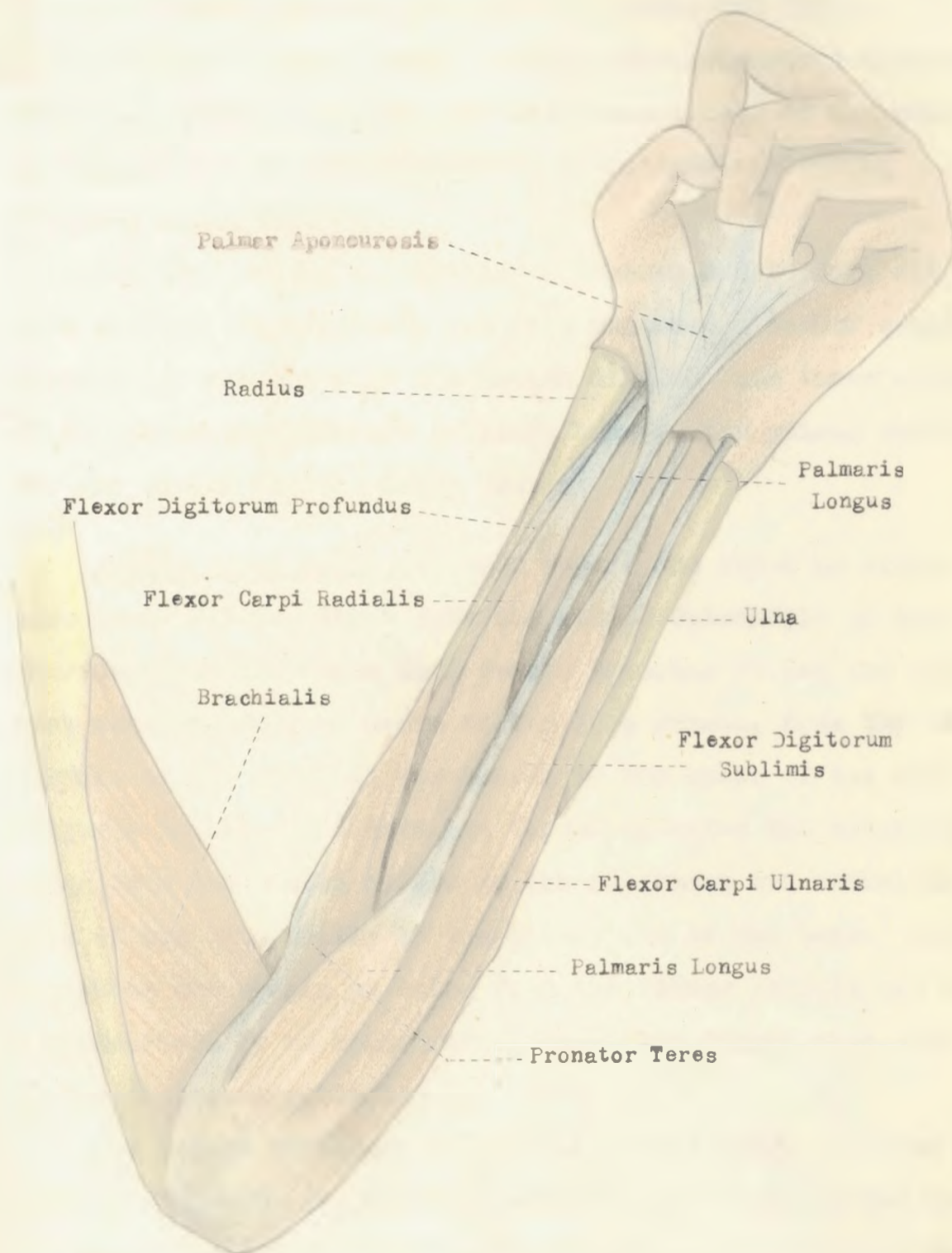
to the Pronator Terres, between these two bony attachments (medial epicondyle and radius) (Figure 12).

The muscle belly converges towards the wrist and there gives rise to a strong tendon which, after passing deep to the small muscles of the thenar eminence, inserts into the ventral surface of the base of the second metacarpal, giving off a small medial slip which attaches to the lateral edge of the base of the third metacarpal.

Sullivan and Osgood describe a similar arrangement to the above, but in addition state that the muscle attaches to the deep surface of the brachio-radialis for a distance of about 30 mm. a little above the radio-carpal joint. They found the insertion to be completely into the base of the second metacarpal, no slips being present.

Sonntag found this muscle fused with the flexor digitorum sublimis and with the pronator terres. The muscle received fibres from the radius down to a point at the junction of the fourth and last fifth of the shaft of the radius. Fick and Langer describes origins as far down as the lower fourth of the radius. Sonntag found the tendon to be inserted into the palmar aspect of the bases of the second and third metacarpals. Beddard mentions the second metacarpal only, but Hepburn records the insertion as the second and third metacarpals.

PALMARIS LONGUS: The muscle takes origin by fleshy and tendinous fibres from the medial epicondyle of the humerus, its fibres being somewhat merged with fibres of origin of Pronator Terres laterally and the Flexor Digitorum Sublimis deeply. It also has some origin from the tough deep fascia covering it and from the adjacent intermuscular septa. It extends downwards in the proximal one-third of the fore-arm

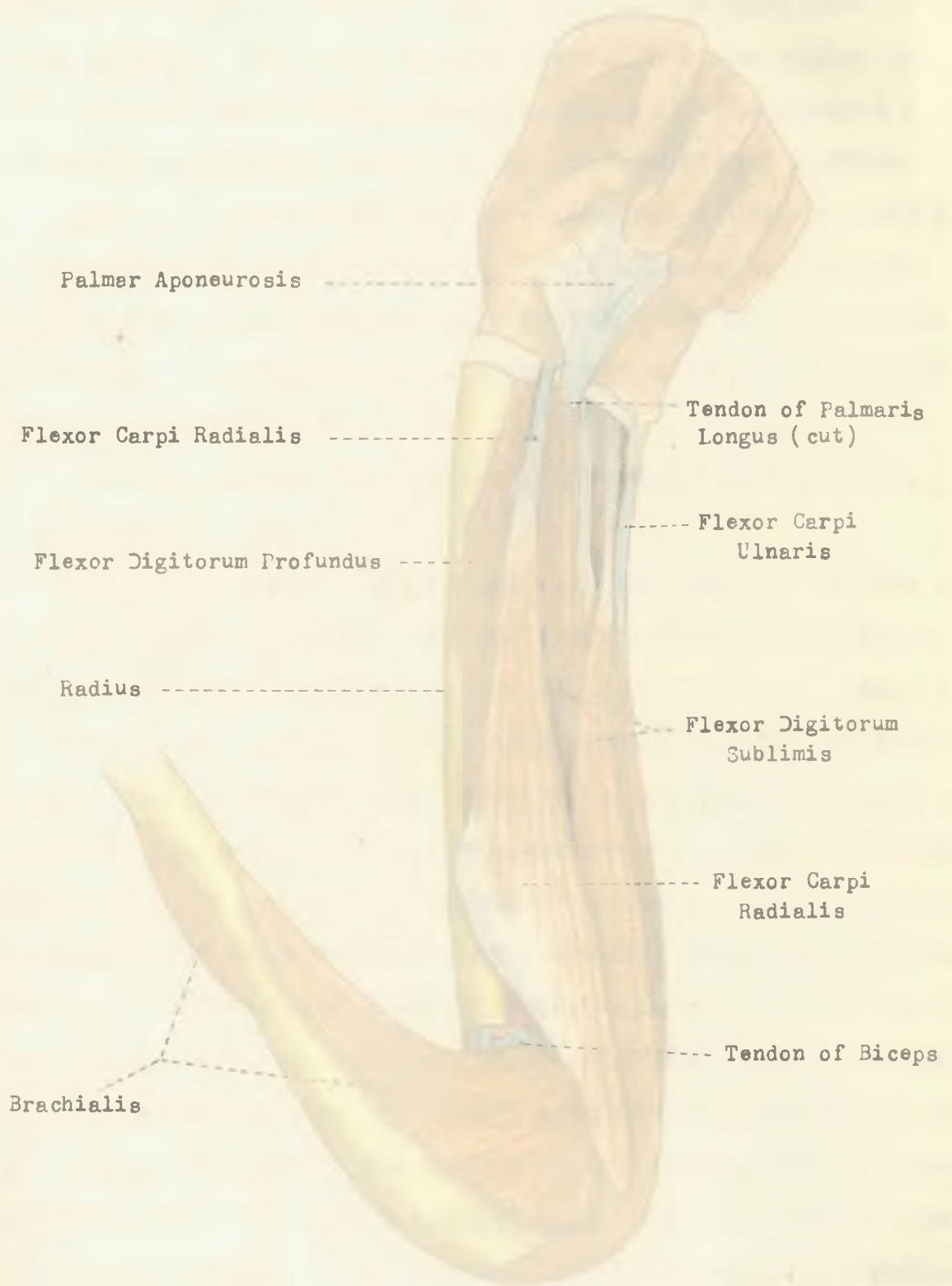


as a spindle-shaped belly of muscle, giving rise to a narrow tendon which runs down on the Flexor Digitorum Sublimis and attaches to the rough flexor retinaculum, then continues down on to the palm of the hand where it widens out fanwise to form the palmar aponeurosis. This palmar aponeurosis embraces mainly the thenar eminence and the lateral half of the palm, the hypothenar eminence receiving a negligible covering (Figures 10,11,12).

Sonntag, Osgood and Sullivan, Hepburn and Seddard all give similar descriptions, but Fick recorded a rather complex muscle. In his specimen the tendon divided into three strips which joined the abductor pollicis brevis, the palmar fascia, and the flexor digiti minimi brevis.

FLEXOR CARPI ULNARIS: This muscle was found to arise by musculo-tendinous fibres from the medial epicondyle of the humerus, from the dense deep fascia covering it and the adjacent muscles, and, by means of the deep fascia, from the medial surface of the proximal two-thirds of the shaft of the ulna (Figures 10,11). Sullivan and Osgood describe the origin as being from the medial margin of the olecranon and medial margins of the ulna nearly to the distal end of the bone. Sonntag describes the origin as being from the flexor condyle and from the olecranon by an aponeurosis, receiving fibres also from the flexor digitorum sublimis.

The muscle converges towards the wrist where it gives rise to a tendon which inserts into the Pisiform bone at the proximal edge of the hypothenar eminence (Figure 12). It now extends distally as two ligaments - the pisohamate joining the pisiform to the hook of the hamate, and the pisometacarpal joining the pisiform to the base of the fifth metacarpal.



FLEXOR DIGITORUM SUBLIMIS: This large muscle was found to arise by musculo-tendinous fibres from (1) the medial epicondyle of the humerus; (2) from the medial ligament of the elbow-joint; (3) from the medial portion of the coronoid process of the ulna, medial to the origin of the deep head of Pronator Terres; (4) from the deep fascia over the region and from the adjacent intermuscular septa; (5) its lateral part attaches by a fibrous sheet to the antero-lateral surface of the shaft of the radius, deep to Flexor Carpi Radialis and deep to insertion of Pronator Terres. This fibrous origin lies superficial to the proximal half of the belly of Flexor Indicis Profundus. The muscle has no fleshy attachment to the radius (Figures 10,11,12,13).

Sonntag, Osgood and Sullivan, record a similar origin for this muscle.

The large mass of the muscle very soon splits up into four separate smaller bellies, each of which gives rise at the wrist to a tendon which supplies one of the medial four digits. These tendons run in the palm of the hand superficial to the tendons of the Deep Flexor muscles. Over the metacarpo-phalangeal joints they split into two equal halves between which pass the corresponding tendon of the deep flexor. The halves of the Sublimis tendons now flatten out and pass laterally round the profundus tendons so that at the proximal interphalangeal joint they lie deep to the profundus tendon. They continue distally in this position till they finally insert into the ventral surface of the lateral borders of the middle of the intermediate phalanx of the medial four digits (Figure 19). Thus they differ from Man in not inserting into the base of the intermediate phalanx.

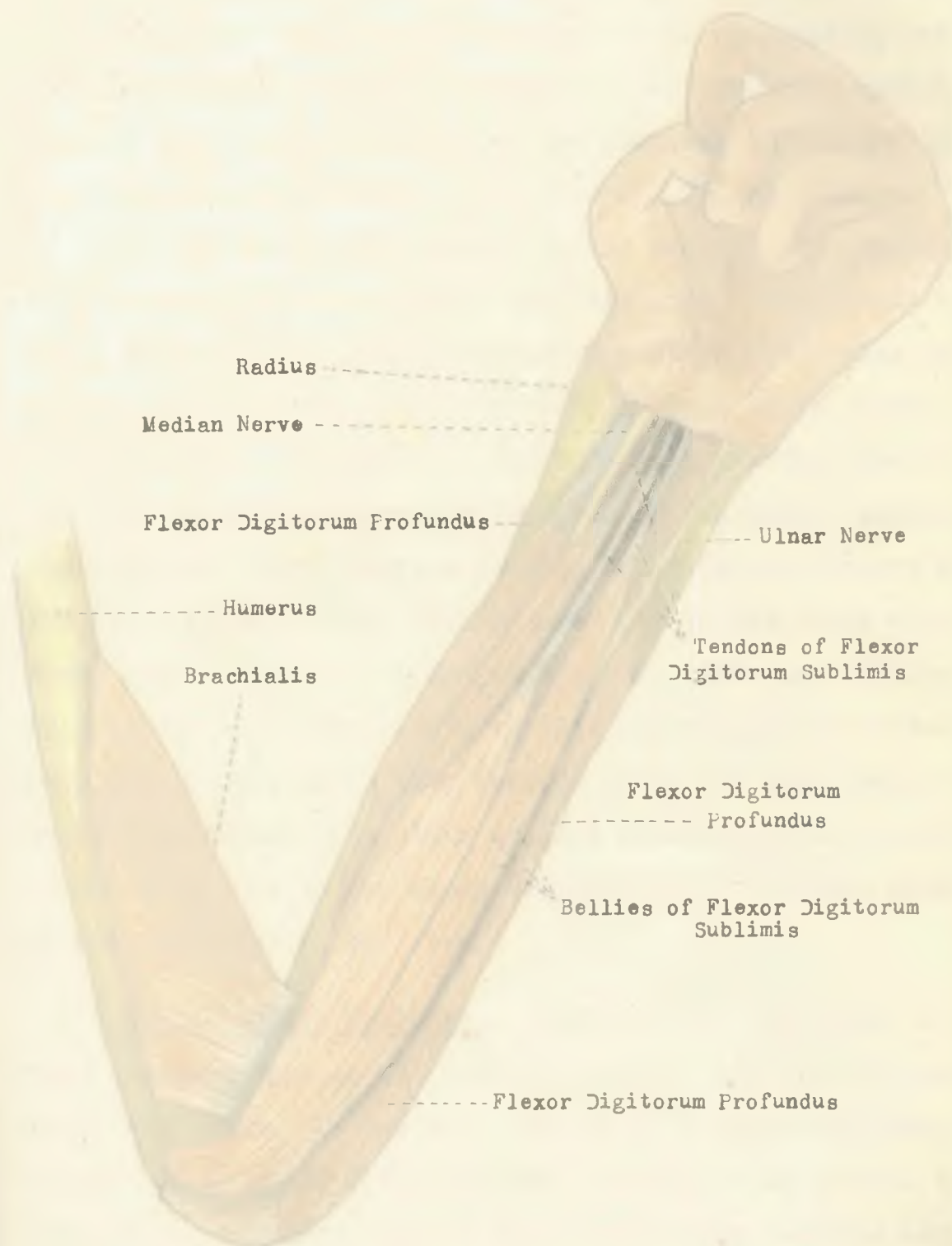


FIGURE 12. DEEPER LAYER OF MUSCLES WORKING TO GRASP FINGER.

FLEXOR DIGITORUM PROFUNDUS: This muscle as described here represents the flexor digitorum profundus^u as it is found in Man, that is, it is the ulnar portion of the deep flexor mass of the forearm. It gained origin from the anterior and lateral surfaces of the proximal three-quarters of the shaft of the ulna, from the medial surface of the proximal half of the shaft of the ulna, from the coronoid process of the ulna medial and distal to the insertion of Brachialis, and from the medial half of the anterior surface of the proximal three-quarters of the interosseous membrane. (Figures 11, 12, 13, 14).

This is the largest muscle in the forearm. In its distal half it can easily be divided into two parts - a superficial and a deep portion. The superficial portion gives rise to one tendon, and the deep portion gives rise to a stout tendon which, under the Flexor Retinaculum splits into two. The three tendons run deep to the corresponding tendons of the flexor sublimis in the hand, and after passing through these finally insert into the bases of the distal phalanges of the medial three digits on their palmar surface. (Figures 19, 20). Sonntag, Sullivan and Osgood, describe this muscle as the "ulnar segment" of the whole deep flexor mass which they include under the term Flexor Digitorum Profundus. This ulnar segment corresponds in description in the main part to the above description of the deep flexor of digits, three, four and five.

FLEXOR INDICIS PROFUNDUS: Sullivan and Osgood and Sonntag have included this as the "radial segment" of their Flexor Digitorum Profundus. It has been treated as a separate muscle here because it is a completely separate muscle in its entire length. Its origin resembles that of the human Flexor Pollicis Longus muscle.

This large and powerful belly of muscle was found to arise

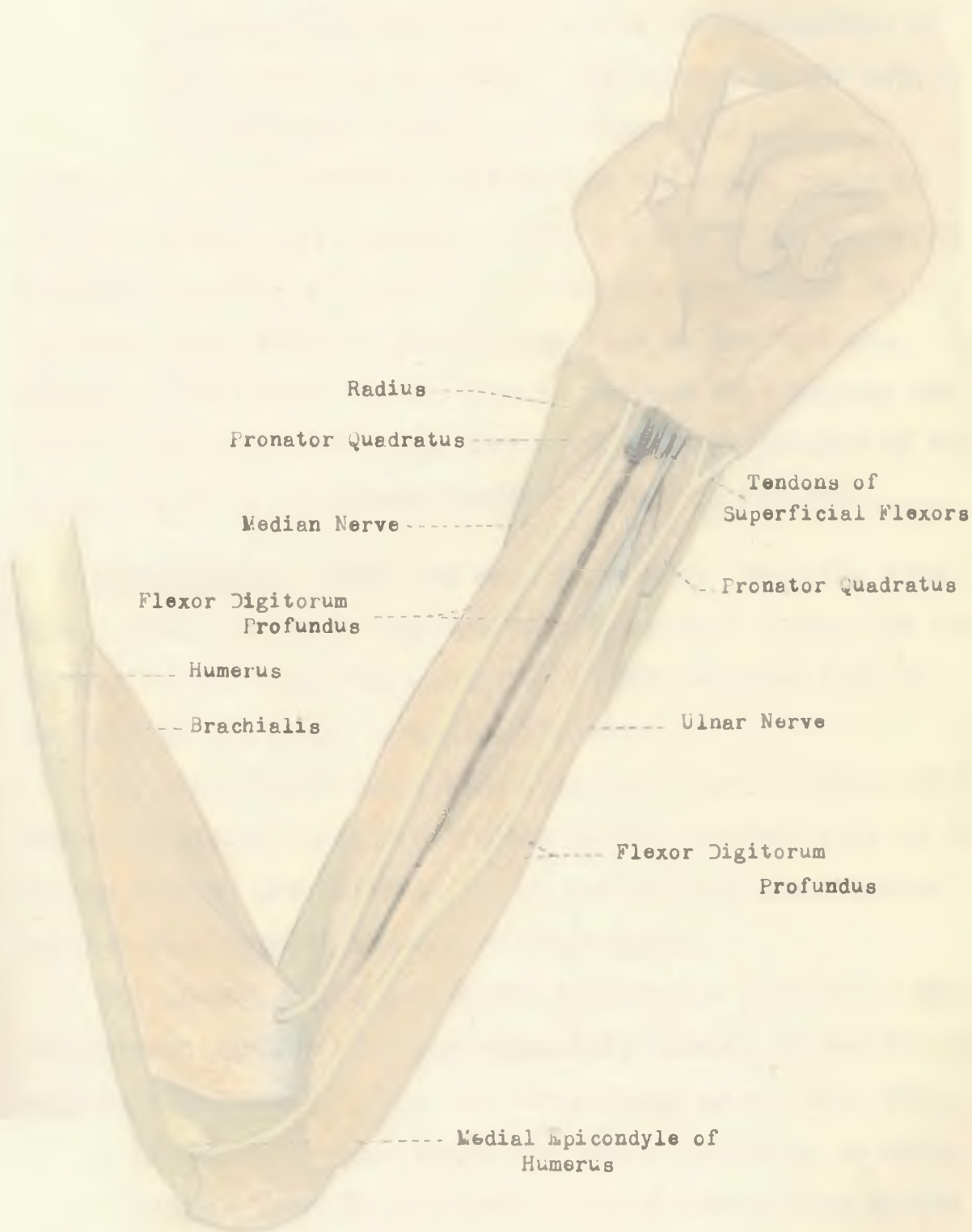


FIGURE 14. MEDIAL VIEW OF RIGHT FOREARM, FLEXED, WITH FIST CLENCHED.

by fleshy fibres from the anterior and medial surfaces of the proximal three-quarters of the shaft of the radius, with the exception of the antero-lateral surface of the proximal one-quarter which is occupied by the Supinator muscle. It also arose from the lateral half of the interosseous membrane in its proximal three-quarters and from the lateral surface of the coronoid process of the ulna, just lateral to the anterior part of the Brachialis insertion. (Figure 14).

The muscle converges downwards to the wrist, where it gives rise to a thick tendon. After passing under the flexor retinaculum, deep to the median nerve and superficial to Pronator Quadratus, the tendon runs deep to the Sublimis tendon to the second digit, then it pierces this tendon, and finally it inserts into the base of the distal phalanx of the second digit on its palmar surface. (Figures 19, 20).

LUMBRICALES: These are four in number. They are long thin columns of muscle arising from the radial surface of the tendons of the deep flexor muscles in the proximal half of the palm of the hand. (Figures 19, 20).

The first lumbrical arises from the lateral surface of the tendon of Flexor Indicis Profundus in the proximal half of its palmar course, and extending up so far as that its proximal portion lies deep to the flexor retinaculum.

The second, third and fourth lumbricales each arise from the lateral surface of their respective tendons of the Flexor Digitorum Profundus. They have no further origin than this.

Sullivan and Osgood found the second lumbrical to arise by two heads - from the adjacent sides of the tendons to the index - and third fingers. Sonntag describes the third lumbrical as arising by a double head, from the adjacent

sides of the tendons to the third and fourth fingers.

The lumbricales proceed distally on the radial side of their respective tendons, the first and second lumbricales having the fibres of the transverse head of Adductor Pollicis deep to them, the third and fourth lumbricales having the fibres of the third and fourth palmar interossei deep to them.

All the muscles insert into the lateral border of the respective extensor digitorum tendons, just at the level of the bases of the proximal phalanges.

PRONATOR QUADRATUS: The muscle takes origin from the anterior surface of the distal one-quarter of the shaft of the ulna, and from the adjacent width of interosseous membrane. Fibres run laterally and slightly distally to insert into the anterior surface of the distal one-quarter of the shaft of the radius. (Figures 15, 15). The proximal fibres insert very near the medial border of the radius, the distal fibres insert very near the lateral border of the radius. Hepburn states that this is a weak muscle whose fibres are very oblique. Fick also describes a small muscle. Sonntag, Sullivan and Osgood, however, describe a muscle closely resembling the one described above.

BRACHIO-RADIALIS: The muscle was found to arise from the upper two-thirds of the lateral supracondylar ridge extending superiorly almost as far as the middle of the shaft of the humerus, but it does not reach up as high as the Deltoid insertion. In all, the origin occupies approximately the lower third quarter of the total length of the shaft of the humerus. The muscle changes in shape at the elbow in such a manner that the middle of the deep fibres of origin come to form the medial border of the muscle



DEEPEST LAYER OF FOREARM, SUPINATOR HAS BEEN REMOVED.

below the elbow, while the middle of the superficial fibres of origin come to form the lateral border of the muscle below the elbow. (Figures 10, 16).

The muscle proceeds distally, forming the lateral border of the forearm, then converges towards the lateral side of the wrist, and giving rise to a flat broad tendon, inserts into the lateral surface of the distal extremity of the Radius. It has a partial insertion into the deep fascia overlying the muscles and tendons in the lower half of the forearm and, more distally, into the superficial layers of the lateral portion of the Flexor Retinaculum.

Sullivan and Osgood record the origin of this muscle as being from the upper three-fifths of the lateral epicondylar line. Sonntag describes the muscle as arising from the upper two-thirds of this lateral supracondylar ridge. He mentions that the muscle consists of two parts - upper and lower - which soon fuse. He does not mention any insertion into the antebrachial fascia, but this is described as a considerable insertion by Sullivan and Osgood.

EXTENSOR CARPI RADIALIS LONGUS: This muscle takes origin by fleshy fibres from the lower one-third of the lateral supracondylar ridge and from the uppermost portion of the lateral epicondyle of the humerus. (Figure 16). This origin seems to be constant through-out the literature. It is a small triangular-shaped muscle which has its origin as its base, and whose apex gives rise to a long thin flat tendon. The muscle belly fits in like a wedge between the proximal parts of the bellies of Brachioradialis and Extensor Carpi Radialis Brevis the muscle belly extending down only the upper one-third of the forearm. The tendon

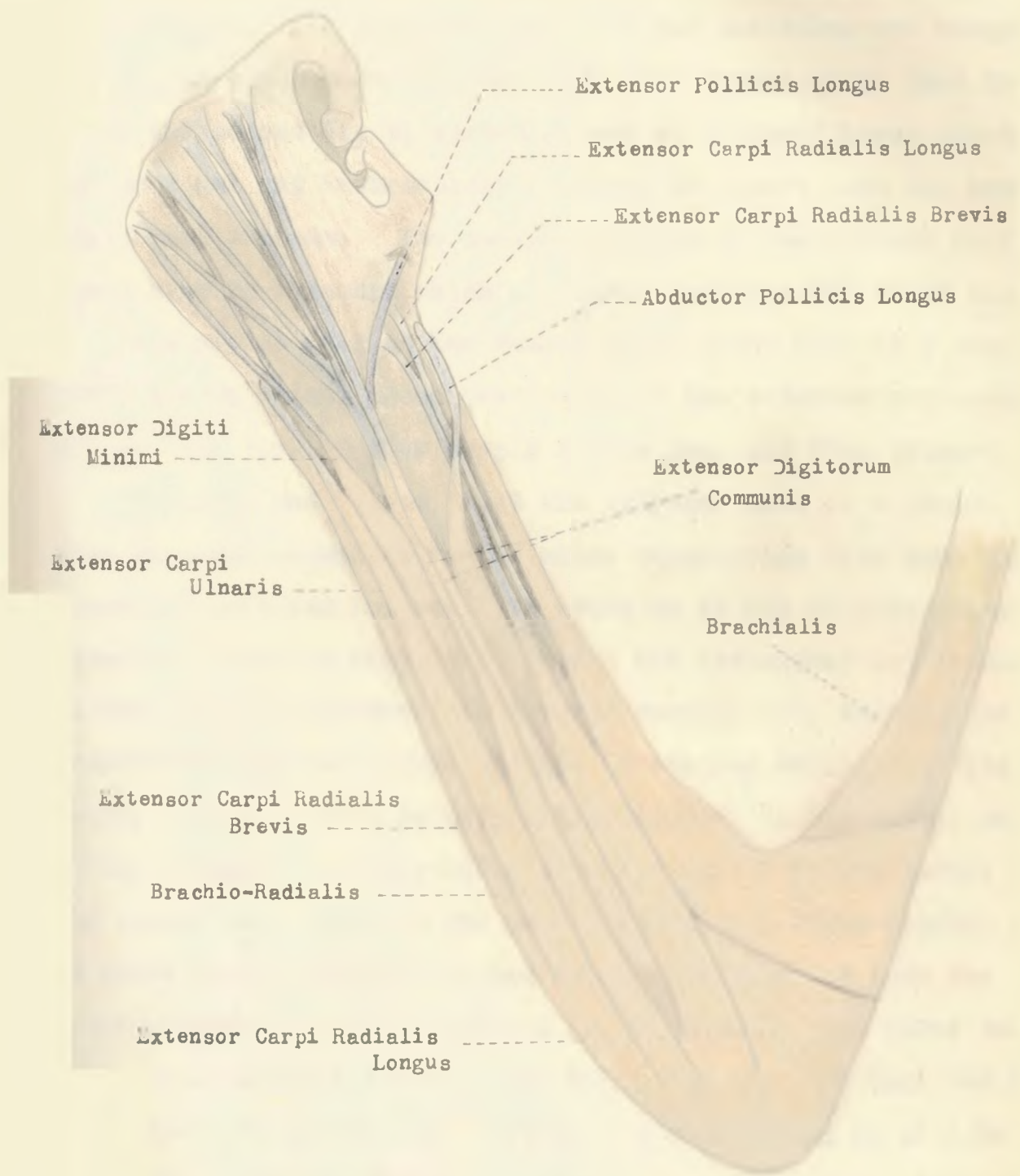
runs distally, deep to the lateral border of the Brachio-radialis, on the lateral border of Extensor Carpi radialis Brevis coming to lie lateral to its tendon, and finally passes deep to the Abductor Pollicis longus and Extensor Pollicis longus to insert upon the dorsal surface of the base of the second metacarpal.

The muscle described by Sullivan and Cogood had a fleshy belly extending downwards for two-thirds of the forearm before it gave rise to its tendon.

EXTENSOR CARPI RADIALIS BREVIS: The muscle was found to take origin by a thin fibro-muscular slip from the lateral epicondyle of the humerus, from the dense deep fascia covering this region, and from the thin but rough inter-muscular septum separating it from the supinator muscle (Figure 16). The medial fibres of origin are fused with the fibres of the Extensor Digitorum Communis near its origin.

The muscle swells out into a large belly which partially overlies the supinator and the shaft of the radius. It gives rise to a long tendon which runs distally, coming to insert into the dorsal surface of the base of the third metacarpal. It is a much larger and more powerful muscle than the Extensor Carpi radialis longus. The literature presents no description differing in any great degree to the above description.

EXTENSOR DIGITORUM COMMUNIS: This muscle was found to arise by tendinous and fleshy fibres from the lateral epicondyle of the humerus, from the dense deep fascia covering the muscle in this region, and from the intermuscular septa separating it from the supinator muscle and from the Extensor Carpi Ulnaris muscle.



Some of its lateral fibres merge with the Extensor Carpi Radialis Brevis.

The belly of the muscle, after running distally a little way, divides into two large equal portions. The lateral half again divides into two, but this time the divisions are unequal. The larger outer portion gives rise to a tendon which goes to serve the second digit, spreading out as a wide fibrous sheet over the proximal and intermediate phalanx, to insert into the base of the distal phalanx. The smaller portion of the lateral half gives rise to a tendon which similarly supplies the third digit.

The medial half of the muscle belly gives rise to a single large tendon which, after passing under the extensor retinaculum, splits into two. They supply digits four and five (Figure 16).

Sullivan and Osgood treat the extensor mass as a whole. That part corresponding to the above description they have called Extensor Digitorum longus. In addition to the origins described above they mention that their muscle had attachment to the dorsal surface of the ulna near its lateral margin, and, through the fascia covering the dorsal surface of the long abductor of the thumb, it may be said to have had attachment to the dorsal surface of the radius. Sonntag describes this muscle in two parts. The larger part supplies the third, fourth and fifth digits, and it takes origin from the common extensor origin and from the septa between it and the muscles on its sides. The other smaller part supplies the second and the third digits. So then the third digit receives two tendons from this muscle. but, as will be seen later, the extensor indicis muscle in Sonntag's animal does not supply digits two and three, as it does in the majority of the oranges, but supplies simply the second digit. Sonntag describes this smaller part as taking origin from the lower parts of the

Internal surfaces of the radius and ulna, the overlying fascia, and the interosseous membrane. Hepburn states that the muscle is as in Men and Fick and Beddard also describe similar conditions

EXTENSOR DIGITIMINI: The muscle arises as part of the Extensor Digitorum Communis mass. It comes off as a separate belly from the medial portion of the main muscle half way down the forearm. The small muscle belly converges downwards towards the ^wrist, and under the Extensor Retinaculum, it gives rise to a small tendon which soon splits into two, - the lateral one going to the fourth digit, the medial one going to the fifth digit. The tendons pass deep to those of the Extensor Digitorum Communis, and like them, spread out over the dorsal surface of the phalanges, and finally insert into the base of the distal phalanx of their respective digits. (Figure 16). Sonntag, Sullivan and Osgood describe a muscle closely corresponding with this.

EXTENSOR CARPI ULNARIS: The origin of this muscle was from the lateral epicondyle of the humerus by muscular and tendinous fibres, from the deep dense fascia over it, from the tough inter-muscular septum covering the supinator, from the dorsal surface of the proximal half of the ulna by fleshy fibres, and from the thin intermuscular septum between it and the mass of the Extensor Digitorum Communis. (Figure 16).

It converges towards the wrist, ^{and} here gives rise to a strong tendon which inserts into the medial surface of the base of the fifth metacarpal. Sullivan and Osgood describe a slightly greater origin from the shaft of the ulna - namely, from the upper three-fifths of the ulna on its dorsal surface and medial margin.

Two Tendons of the
Extensor Indicis

Tendon of the
Extensor Pollicis Longus

Extensor Indicis

Radius

Ulna

Extensor Pollicis
Longus

Abductor Pollicis
Longus

Supinator

Brachialis

Lateral Supra-
condylar Ridge of
Humerus

Anconeus

ANCONEUS: This small muscle arises from the inferior and posterior surfaces of the lateral epicondyle of the humerus. The fibres diverge fanwise distally and medially, to insert into the elongated triangular area on the postero-lateral surface of the proximal part of the ulna, lateral to the insertion of triceps. A dense and very tough fascia covers the muscle completely. (Figure 17).

SUPINATOR: The origin of this large muscle was found to be by fibro-muscular attachment from the lateral epicondyle of the humerus, from the postero-lateral surface of the proximal portion of the shaft of the ulna, just distal to the insertion of the Anconeus, and from the superficial surface of the upper portion of the tendon of origin of the Abductor Pollicis Longus.

The fibres pass laterally and downwards round the upper portion of the radius to insert into the posterior surface of the proximal second quarter of the shaft of the radius posterior and lateral to the insertion of the Pronator Terres, and also into the lateral and anterior surfaces of the shaft of the radius, between the attachment of the capsule of the elbow-joint to the bone and the insertion of Pronator Terres. The muscle has a dense tough fibrous sheet covering it on its posterior and lateral surfaces. (Figure 17). The descriptions of this muscle given by Sonntag, Os good and Sullivan correspond closely with the above.

ABDUCTOR POLLICIS LONGUS: The muscle was found to arise by tendinous fibres from the dorso-lateral surface of the shaft of the ulna in its upper part, just distal to the attachments of the Supinator muscle; from the dorso-medial surface of the radius for a short distance just medial to the distal portion of the insertion of the Supinator and extending downwards on the lower one-third of

the radius in a triangular-shaped attachment. It also arises by fleshy fibres from the dorsal surface of the interosseous membrane between these two bony origins.

Sullivan and Osgood give a different description of the origin of the muscle. They find the muscle arises from the dorsal surface of the radius in its distal half falling short of the radio-carpal joint by about 30 mm. Proximally the origin reaches the Supinator muscle. Here some of the more medial fibres have an attachment to the interosseous membrane and ulna.

The muscle belly passes laterally and forwards round the radius, converging as it goes, and having crossed superficially over the tendons of Extensor Carpi Radialis Longus and Brevis, it gives rise to a single stout tendon, which, after grooving the radius, inserts into the lateral surface of the base of the first metacarpal. (Figure 17).

Sullivan and Osgood describe their muscle as separating into two parts, a little below its middle. The more ventral segment in turn has two tendons. The tendon of the dorsal segment and the smaller tendon of the ventral segment are attached to the proximal end of the first metacarpal. The larger tendon of the ventral portion attaches to the volar surface of the greater mult-angular bone. They state that this muscle has been described as representing both the long abductor and the short extensor

EXTENSOR POLLICIS LONGUS: This muscle arose by fleshy fibres from the dorso-lateral surface of the shaft of the ulna immediately distal to the origin of the Abductor Pollicis Longus. It occupies one-sixth the length of the ulna. It also took origin from the dorsal surface of the interosseous membrane, between the Abductor Pollicis Longus and Extensor Indicis muscles.

The muscle belly is rather small and thin, and it gives rise to a small tendon which passes distally to the wrist joint and then

turns laterally, running along the pollex, to insert into the dorsal surface of the base of the distal (that is, second) phalanx of this digit. (Figure 17).

Sullivan and Osgood describe this muscle as also having a radial origin largely through the fascia of the long abductor of the thumb.

EXTENSOR INDICIS: This completely separate muscle belly was found to arise by fleshy fibres from the dorso-lateral surface of the lower third quarter of the shaft of the ulna, and from the adjacent interosseous membrane in a triangular manner - the base being distal and the apex proximal and against the lateral border of the ulna.

The distal portion of the muscle splits into two bellies, each giving rise to a tendon of equal size. The lateral tendon inserts into the base of the proximal phalanx of the second digit and spreads out into the extensor sheet on the dorsum of the digit.

The medial tendon inserts similarly into the third digit.

(Figure 17).

Sullivan and Osgood include this muscle with the Extensor Digiti Minimi, calling the whole the "Extensor Digitorum Brevis". This muscle, the extensor indicis, forms the "lateral segment" of this Extensor Digitorum Brevis. They describe the origin as being from the interosseous membrane and from the adjacent margins of the radius and ulna in the upper part of the distal third of the forearm. Insertion is into digits 2 and 3.

Sonntag describes the muscle as giving rise to only one tendon, - which inserts into the base of the second digit.



FIGURE 14. PALMAR SURFACE OF LEFT HAND [X 1½]

MUSCLES OF THE HAND.

ABDUCTOR POLLICIS BREVIS: The muscle took origin by fleshy fibres from the anterior surface of the radial half of the Flexor Retinaculum, the origin being almost circular in shape. It also gains attachment from the lateral portion of the insertion of Palmaris Longus and the Palmar Aponeurosis. (Figure 19).

It inserts by a flat tendon into the radial surface of the base of the proximal phalanx of the Pollex and into the lateral border of the tendon of Extensor Pollicis Longus.

Sullivan and Osgood describe a small attachment to the greater multangular bone. Sonntag maintains that this muscle arises entirely from the anterior annular ligament.

OPPONENS POLLICIS: This muscle was found to arise by fleshy fibres from the disto-lateral border of the Flexor Retinaculum and from the crest and ventral surface of the trapezium.

Sullivan and Osgood describe this muscle in two segments. The superficial segment apparently passes from the ridge of the greater multangular bone to the lateral side of the distal end of the metacarpal. At a deeper level lies the larger segment. It has an extensive origin from the ridge of the greater multangulum and from the transverse carpal ligament.

The insertion of the muscle was found to be by fleshy fibres into the lateral surface of the distal two-thirds of the first metacarpal bone. (Figure 20).

Sullivan and Osgood describe the insertion as being into the lateral surface of the shaft of the metacarpal throughout its length.

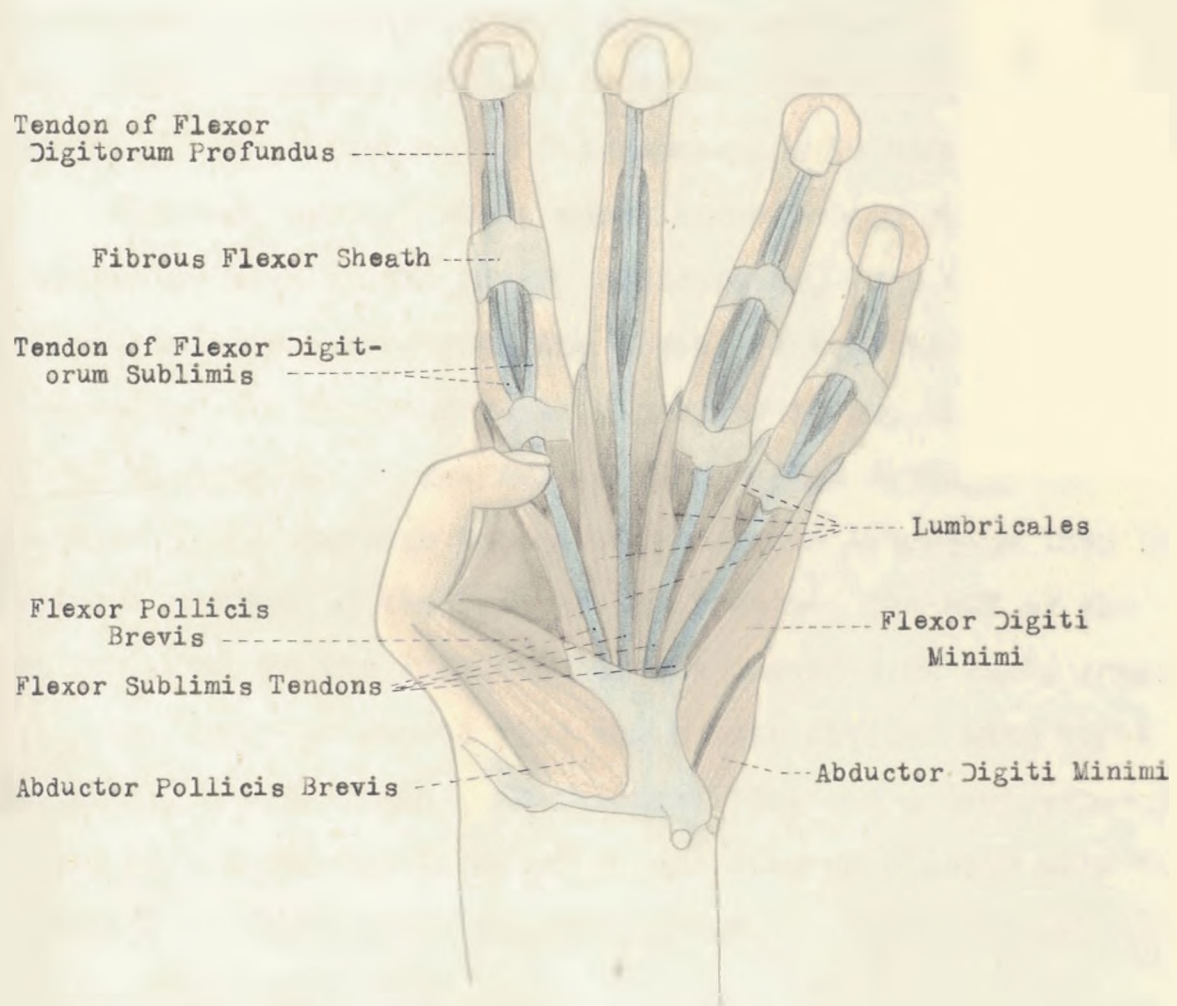


FIGURE 19. DEEP MUSCLES OF THE HAND: SUPERFICIAL LAYER (X 2½)

Flexor Pollicis Brevis: This stout little muscle is divided into two well-defined parts, a superficial and a deep part.

The superficial portion arises by somewhat aponeurotic fibres from the disto-lateral portion of the flexor retinaculum, deep to the origin of the anterior half of the Apponens. It also gains a small bony origin from the distal end of the crest of the Trapezium. The fibres pass disto-laterally and insert into the lateral surface of the base of the proximal phalanx of the Pollex. The insertion is fibro-muscular in nature. (Figure 19).

The deep portion has a much larger origin from the disto-lateral portion of the Flexor retinaculum, deep to the origin of the superficial part, from the distal part of the crest of the trapezium, and from the ventral surface of the shaft of the first metacarpal. The muscle fibres pass distally and laterally, to converge to a fibro-muscular insertion into the lateral surface of the base of the proximal phalanx of the Pollex, deep to the insertion of the superficial part. (Figure 20).

Sullivan and Osgood find the muscle divided into three segments, a superficial, an intermediate, and a deep segment. Taken as a whole the description corresponds closely with the above. Sonntag describes this muscle as being divided into an outer and an inner head.

Adductor Pollicis: The muscle cannot be satisfactorily divided into an Oblique and a Transverse head, it being really one continuous sheet of muscle. It has an extensive origin from the tough fibrous septa between the first dorsal interosseous and the second palmar interosseous, between the second palmar interosseous and the second dorsal interosseous, and from the septa on the medial side of the last named muscle which attaches to the palmar surface of the shaft of the third metacarpal.

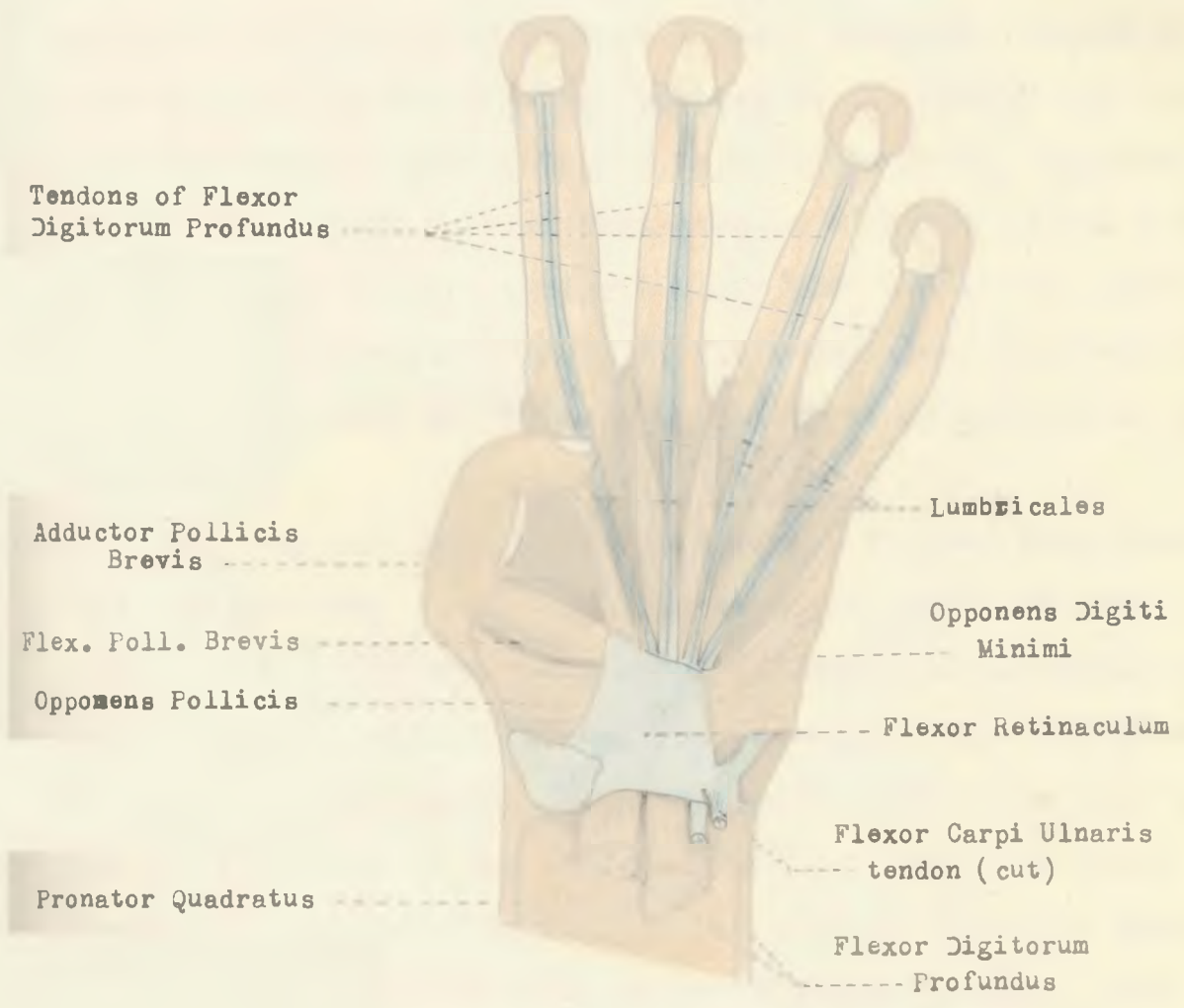


FIG. 28. RIGHT WRIST AND HAND, SUPERFICIAL MUSCLES REMOVED.

(X 1½)

It gains further origin from the palmar surface of the bases of the second and third metacarpals, from the ventral surface of the tendons of insertion of Flexor Carpi Radialis, from the ventral surface of the distal portion of the capitate bone, and finally from the dense fascia covering the adjacent interosseal muscles.

The superficial portion of the proximal part of the muscle separates off and gives rise to a small cord-like tendon which runs close along the proximal phalanx of the pollex and inserts into the ventral surface of the base of the distal phalanx of the pollex. This portion then acts as a Flexor of the distal phalanx of the Pollex. (Figure 21). The rest of the muscle converges and inserts by a large fibro-muscular insertion into the medial surface of the base of the proximal phalanx of the Pollex.

Sullivan and Osgood find this muscle divided into three distinct portions - oblique, transverse, and a third more dorsal part. The transverse head is described as taking origin from the third metacarpal and, more distally, from the second metacarpal. It inserts into the medial side of the base of the first phalanx. The oblique head comes from the bases of the second and third metacarpals and from the capitate bone. Its fibres insert with those of the transverse head. The third and most dorsal segment arises immediately adjacent to the transverse head from the second metacarpal and the fascia between the second and third. It inserts into the medial side of the distal end of the shaft of the first metacarpal.

Sonntag finds the muscle divided into distinct Transverse and Oblique heads, though these were closely in contact with one another. This author points out that this muscle is the only representative in the *Cyrtang* of the *contrahentes* group of

Tendons of Flexor
Digitorum Profundus (cut)

Small tendon from proximal
portion of the
Add. Pollicis Brevis

Flexor Retinaculum

Pronator Quadratus

Interossei

Adductor Pollicis
Brevis

Flexor Carpi Ulnaris
tendon (cut)



FIGURE 21. DEEP LAYERS OF THE RIGHT WRIST AND HAND.

(x 1½)

muscles described by Bischoff, Cunningham, Halford and Hepburn.

ABDUCTOR DIGITI MINIMI: The muscle is found to arise from the distal surface of the pisiform bone, from the attachment of the Flexor Retinaculum to the pisiform bone, and from the palmar surface of the thick tendon joining the pisiform to the base of the fifth metacarpal. (Figure 19). It converges distally giving rise to a thin tendon half way down the palm of the hand. This tendon is embraced by the medial fibres of the Flexor Digiti Minimi muscle, but these fibres have apparently no attachment to the tendon. It inserts into the medial surface of the base of the proximal phalanx of the fifth digit.

OPPONENS DIGITI MINIMI: This muscle arises from the disto-medial portion of the Flexor Retinaculum, deep to the origin of the Flexor Digiti Minimi, the most proximal fibres gaining a very small attachment to the hook of the hamate bone. The muscle spreads out fan-wise in a disto-medial direction and inserts into the medial border of the whole of the shaft of the fifth metacarpal, except for the base of the shaft, into which inserts the extensor carpi ulnaris tendon. (Figure 20).

The literature presents no description which differs from the above.

FLEXOR DIGITI MINIMI: The muscle arises from the disto-medial border of the Flexor Retinaculum and from the hook of the hamate bone. It runs distally and slightly medially, forming the lateral portion of the hypothenar eminence. (Figure 19).

It converges, giving rise eventually to two insertions. The first, from the lateral half of the muscle, is by a short thin tendon into the medial surface of the base of the proximal

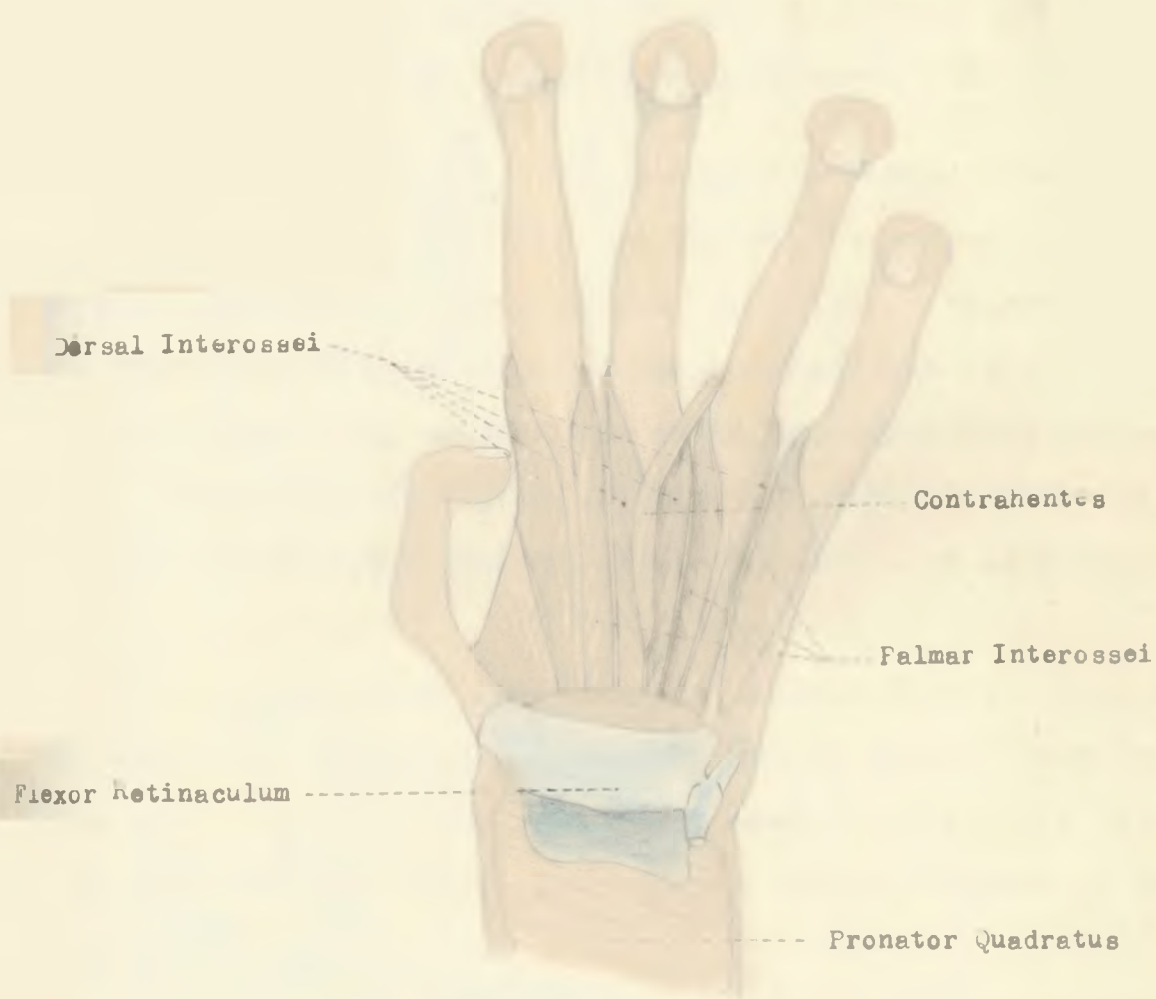


FIGURE 17. DEEP MUSCLES OF THE HAND & PALMAR APERTURE.

(x 1½)

phalanx of the fifth digit, along with the insertion of Abductor Digiti Minimi. The second insertion is by fleshy fibres into the medial border of the long extensor tendon supplying the fifth digit, this insertion being at the same level as the first insertion, but extending a little more distally.

Sullivan and Osgood find the origin of this muscle only from the ulnar end of the transverse carpal ligament. They do not mention the attachment with the long extensor tendon.

PALMAR INTEROSSEI: These small muscles, placed between the metacarpals, act as adductors of the digits towards the median axis of the hand. There are four in number. (Figure 23). The first palmar interosseus^{us} is the smallest one of all. It arises from the ulnar side of the base of the proximal half of the shaft of the first metacarpal, and it inserts into the ulna side of the base of the proximal phalanx of the pollex. It is a very weak muscle.

The second palmar interosseous arises from the ulna side of the shaft of the second metacarpal, and it inserts into the ulnar side of the proximal phalanx of the second digit. It also has an insertion into the medial edge of the Extensor tendon of this second digit.

The third palmar interosseous arises from the radial surface of the fourth metacarpal and inserts into the radial side of the base of the proximal phalanx of the fourth digit. It also inserts into the lateral edge of the extensor tendon of the fourth digit.

The fourth palmar interosseous arises from the radial surface of the shaft of the fifth metacarpal. It inserts into the radial side of the base of the proximal phalanx of the fifth digit and into the lateral edge of the Extensor tendon of this digit.

There is another muscle present at this level in the hand,

which has the same function as a palmar interosseous, namely, adducting a digit towards the axis of the hand. It is a contrahentes muscle. It is smaller and much thinner than the second, third and fourth palmar interossei, being only two-thirds of the length of these muscles. It arises from the edge of a tough fibrous septum which lies between the third dorsal and the third palmar interossei. It also receives attachment from the fibrous covering of the adjacent origin of Adductor pollicis. It crosses and covers the distal half of the third dorsal interosseous and then it inserts together with the tendon of the third palmar interosseous into the lateral edge of the Extensor tendon of the fourth digit.

Sullivan and Osgood as well as Montagu only describe three palmar interossei, which apparently, is the usual number to be found in the hand of the Orang. Further, they do not mention any contrahentes muscle (besides the Adductor pollicis) as being present.

DORSAL INTEROSSEI: These are four in number. All are bipennate in structure and act as abductors of the medial four digits from the median axis of the hand. (Figure 23).

The first dorsal interosseous is much larger than the others. It arises by two heads; the larger from the radial surface of the shaft of the second Metacarpal. the other from the ulnar surface of the proximal half of the shaft of the first metacarpal. It inserts into the radial side of the base of the proximal phalanx of the second digit, and into the lateral edge of the extensor tendon of that digit.

The second dorsal interosseous arises from the radial surface of the third metacarpal and ulnar surface of the second metacarpal. It inserts into the radial side of the base of the proximal phalanx of the third digit and also into the lateral edge of the

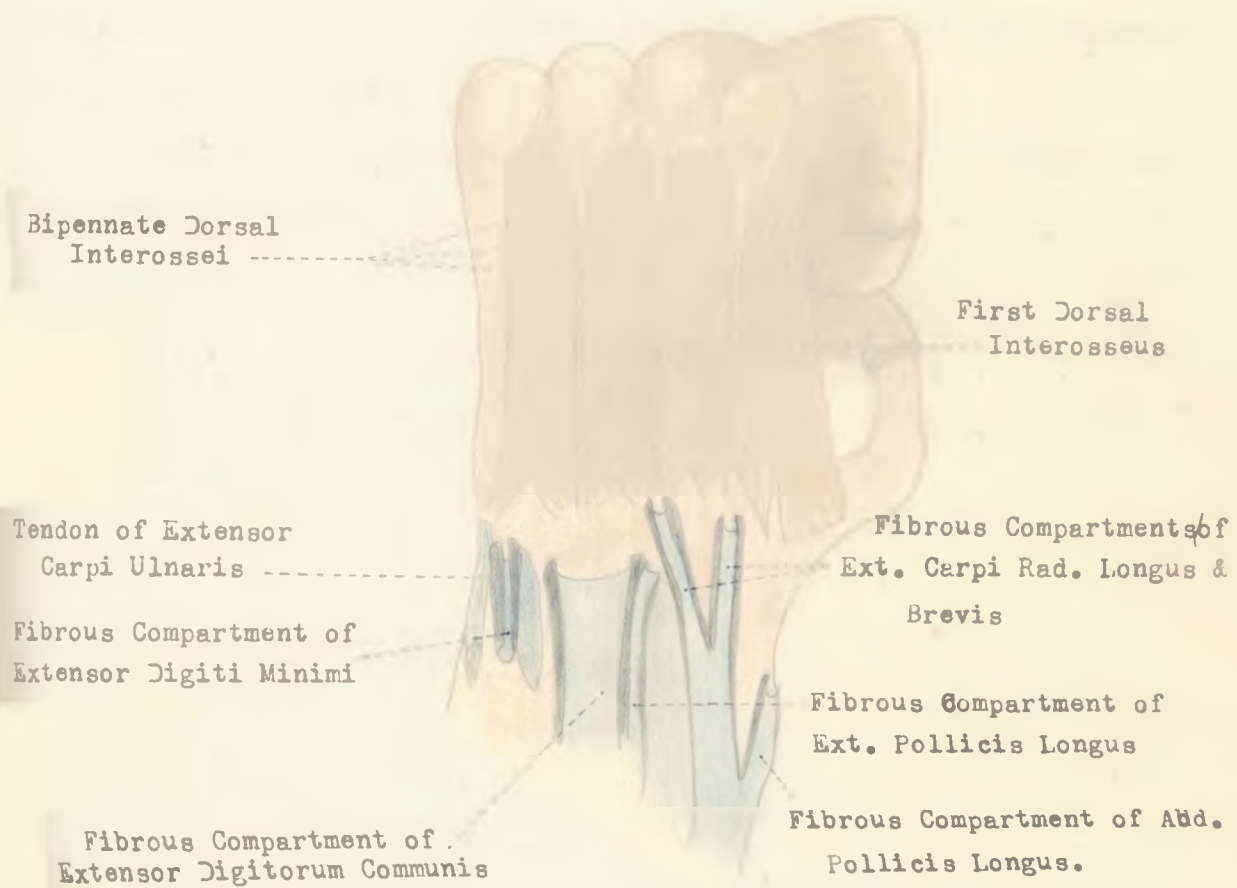


FIGURE 23. DORSAL INTEROSSEI OF THE HAND. (X 12)

extensor tendon of that digit.

The third dorsal interosseous arises from the ulnar surface of the third metacarpal and the radial surface of the fourth. It inserts into the ulnar side of the base of the proximal phalanx of the third digit and into the medial edge of the extensor tendon of that digit.

The fourth dorsal interosseous arises from the ulnar side of the fourth metacarpal and radial side of the fifth metacarpal. It inserts into the ulnar side of the base of the proximal phalanx of the fourth digit and into the medial edge of the extensor tendon of that digit.

Sonntag, Sullivan and Osgood give similar descriptions of the dorsal interossei.

MUSCLES OF THE LOWER LIMB.

MUSCLES OF THE GLUTEAL REGION.

~~XXXXXXXXXXXXXXXXXXXXXXXXXXXX~~

GLUTEUS MAXIMUS: This muscle was found in two quite separate parts. The upper part was found to arise from the dense sheet of fascia covering the Gluteus Medius, from the lower posterior portion of the iliac crest, from the dorsum of the sacrum and from the dorsum and tip of the coccyx. It has a triple insertion; into the fascia lata, into the Gluteal tuberosity on the lateral surface of the shaft of the femur in its upper third, and into the lateral inter-muscular septum. (Figures 1, 2, 24, 25, 26).

The fibres which arise from the iliac crest by means of the tough fibrous sheet covering gluteus medius, pass laterally and downwards to insert into the fascia lata, that is, into the ilio-tibial tract. The lower fibres, which arise from the Sacrum and Coccyx, pass laterally and slightly downwards and give rise to a broad flat tendon which passes deep to the Fascia Lata attachment, and then twists slightly, so as to insert into the gluteal tuberosity on the lateral side of the upper one-third of the femur. The lower border of this tendon of insertion becomes merged into the lateral intermuscular septum. (Figures 25, 26).

The lower part of the muscle, which is quite distinct and separate from the above portion, arises from the whole of the lateral side of the "Common Hamstring Tendon" and from the ischial tuberosity, the upper part being mostly fibrous, while the lower part is fleshy. It also has a considerable attachment to approximately half of the tendon of intersection of the upper part of Gluteus Maximus into the Gluteal tuberosity, the tendon being deep to it. The muscle belly passes downwards and laterally inserting into the lateral intermuscular septum, especially in its lower half, and into the fascia lata on the adjacent side, posterior to the lateral intermuscular septum. Its insertion is about twice as



FIGURE 14. MEDIAL VIEW OF RIGHT SUPERFICIAL MUSCLES AND FASCIAE.

extensive as its origin. It may be taken as part of the Biceps femoris owing to its close association with the origin of the long head of Biceps. (Figures 25, 26, 27, 28).

Sonntag also describes two parts to the Gluteus Maximus. His upper part took origin from the sacrum and great sacro-sciatic ligament, while the lower part arose from the ischial tuberosity and became closely fused with the short head of the Biceps. Thus, these two parts appear to correspond with the two parts described above. Sonntag mentions that the interval between the two parts was not as great as that described by Hepburn.

Fick states that there is no macro-tuberous ligament in the Orang and this was found to be the case with this animal dissected.

The gluteus maximus as described by Boyer represents only the upper part of the muscle described above. The descriptions of this upper part, however, correspond quite closely.

GLUTEUS MEDIUS: This was found to be by far the most predominant muscle of the Gluteal group. It arises from the whole of the dorsal surface of the ilium between the greater sciatic notch, the anterior superior iliac spine and the iliac crest. It has also a considerable origin from the tough fascia covering it which attaches to the outer lip of the Iliac crest. (Figures 25, 26).

It inserts into the upper border of the Greater Trochanter in its posterior half, and into the whole of the lateral surface of the greater trochanter, the anterior portion of the tendon inserting furthest down on the bone. (Figure 26).

Boyer and Sonntag describe very similar origin for this muscle. The former worker, however, gives the insertion as being only into the superior portion of the greater trochanter. The close association between this insertion and that of the pyriformis muscle is stressed by both.

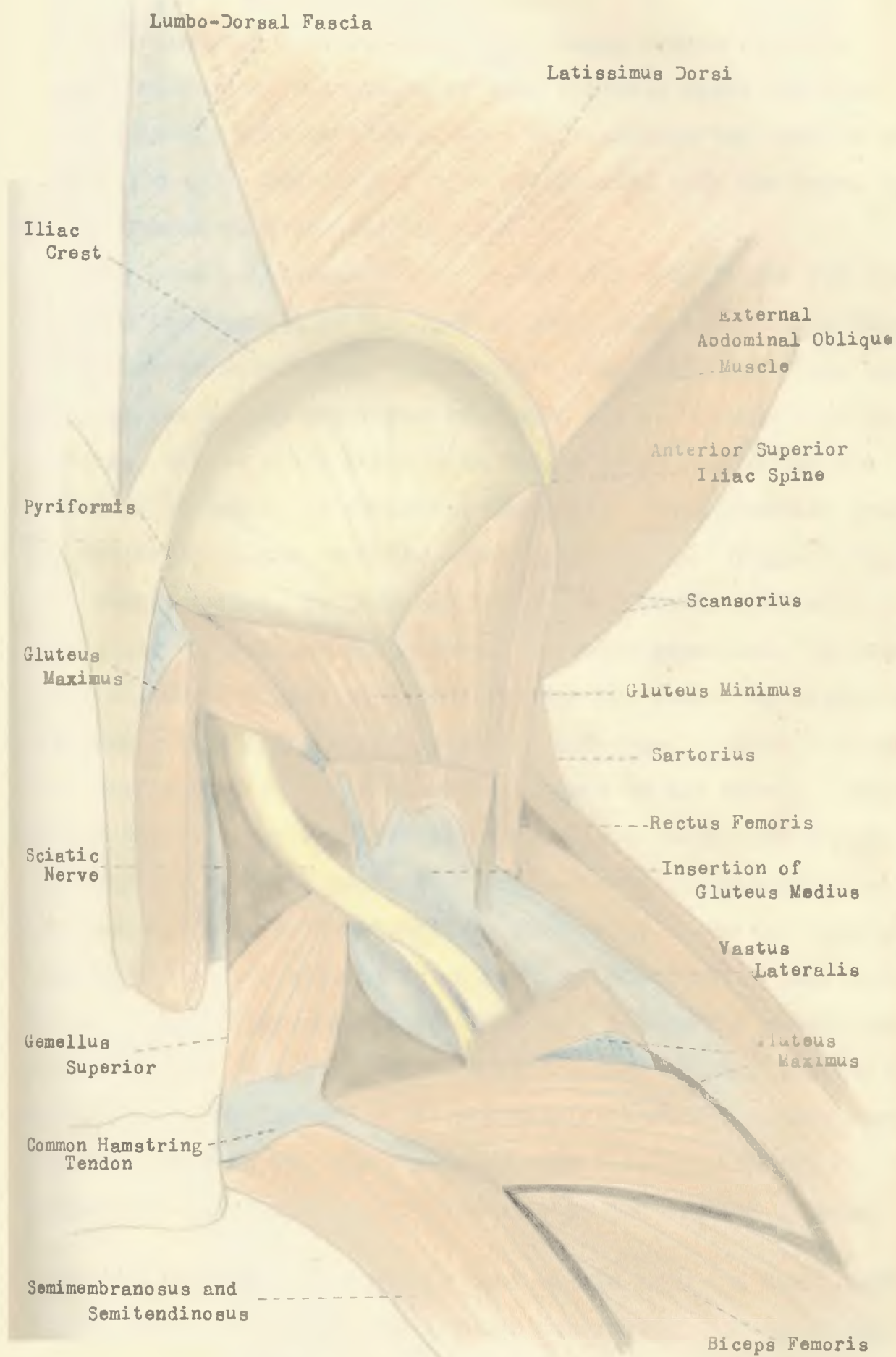


FIGURE 17. GLUTEAL REGION - DEEP LATERAL VIEW (Approx. X 2)

SCANSORIUS: This characteristic Orang muscle was found to arise from the anterior portion of the dorsum of the ilium extending from the Anterior Superior Iliac Spine downwards to just 2-3mm. above the upper lip of the acetabulum. The muscle passes directly distally and converges to a short round tendon which inserts into the upper antero-lateral corner of the Greater Trochanter of the femur. (Figures 27, 30, 31).

Sonntag states that this muscle has been homologized with the dorso-epitrochlearis of the arm. Pick points out that it possesses the same function as the gluteus minimus, with increased power of internal rotation. Boyer gives a similar origin for the muscle and says that the insertion is upon the anterior border of the greater trochanter, the tendon being embraced by the tendon of origin of the vastus lateralis. Primrose gives a complete discussion of the literature on the scansorius, and from this it appears that the muscle is closely associated with the gluteus medius and minimus, and more especially with the latter.

GLUTEUS MINIMUS: The muscle took origin from the middle half of the bony border of the greater sciatic notch continuing down to the ischial spine and from a large area of bone adjacent to this, extending laterally as far as the origin of the Scansorius. (Figure 27). It inserts into the anterior surface of the greater trochanter of the femur. There is a clockwise twist on the tendon of insertion on the right side and an anti-clockwise twist on the tendon on the left side.

Boyer reports that a few fibres of this muscle take origin from the sacro-spinous ligament. She reports the insertion to be into the lateral surface of the greater trochanter underneath the lateral edge of the gluteus medius and just superior and in line with the attachment of the Scansorius. Sonntag describes the insertion as being into the anterior border of the great

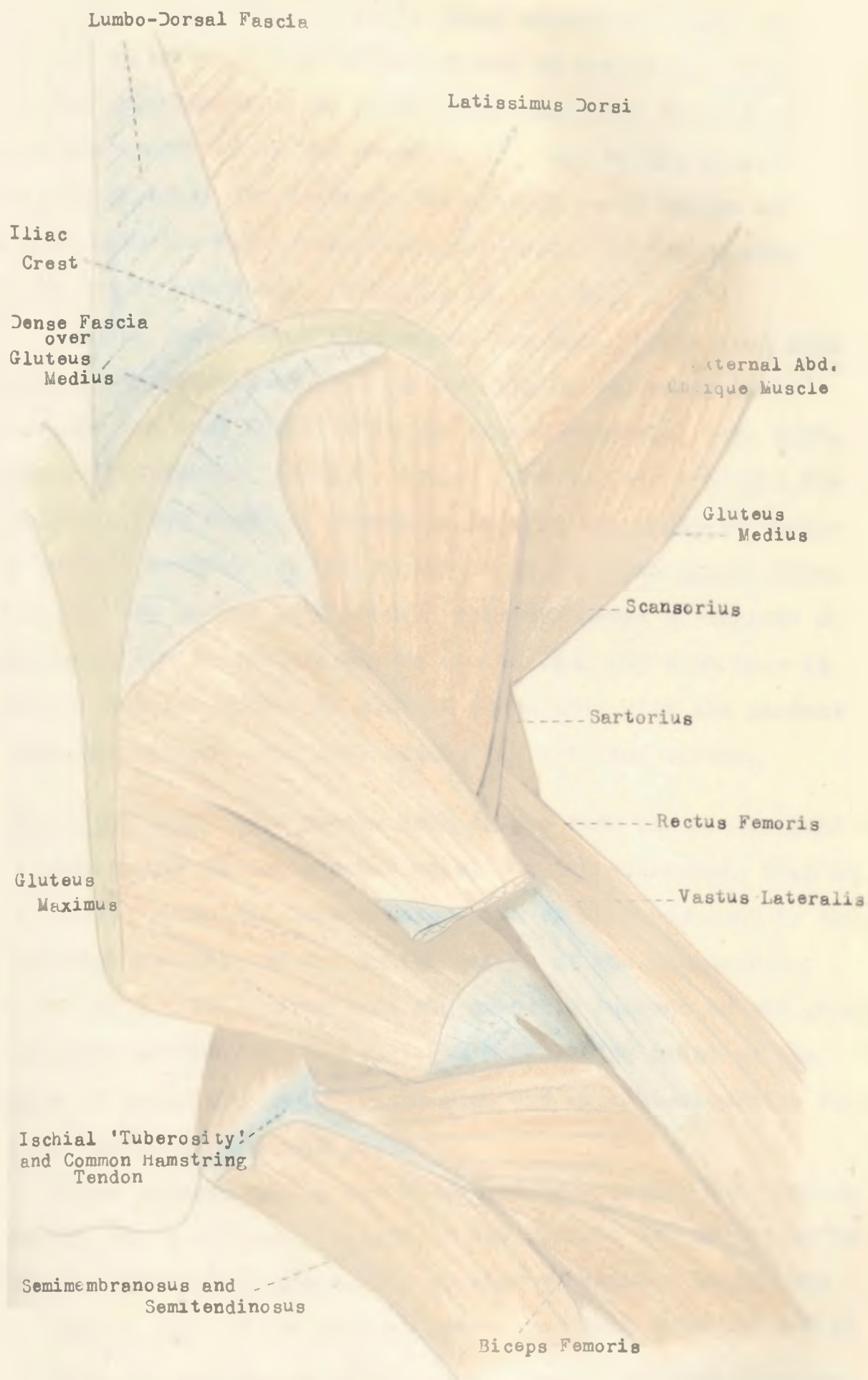


FIGURE 12. LATERAL VIEW OF THE RIGHT THIGH AND HIP REGION, SURFICIAL MUSCLES (APPROXIMATE)

trochanter, in close association with the scansorius.

PIRIFORMIS: This muscle took origin by fleshy fibres from the lateral half of the anterior surface of the middle one-third of the sacrum. The muscle fibres pass laterally and emerge from the pelvis via the greater sciatic notch and the muscle then comes into close association with the gluteus medius. (Figures 26, 27). It inserts by a tendon into the upper border of the greater trochanter of the femur in very close association with the insertion of the gluteus medius into the upper border of this greater trochanter. It appears to have no fibres of origin from the upper border of the greater sciatic notch.

Boyer describes a fusion between the muscle fibres of this muscle with those of the gluteus medius, these two muscles inserting by one completely fused tendon into the upper portion of the greater trochanter. Primrose found this muscle to be a narrow ribbon-like band which could be easily separated from the gluteus medius. Hepburn found this muscle intimately fused with the fibres of gluteus medius, but its tendon of insertion was separate.

OBTURATOR INTERNUS AND GEMELLI: The obturator internus took origin from the pelvic surface of the medial and posterior bony margins of the obturator foramen and from the greater part of the pelvic surface of the obturator membrane, the origin not extending to the most anterior part of this membrane. It also gains some attachment from the fascia covering it. The fibres of the muscle pass backwards and laterally, converging as they go, to pass out of the pelvis round a slight groove in the upper or lateral ramus of the ischium which must represent the lesser sciatic notch. The muscle is now joined by the gemelli and it gives rise to a stout tendon which inserts into the greater trochanter of the femur

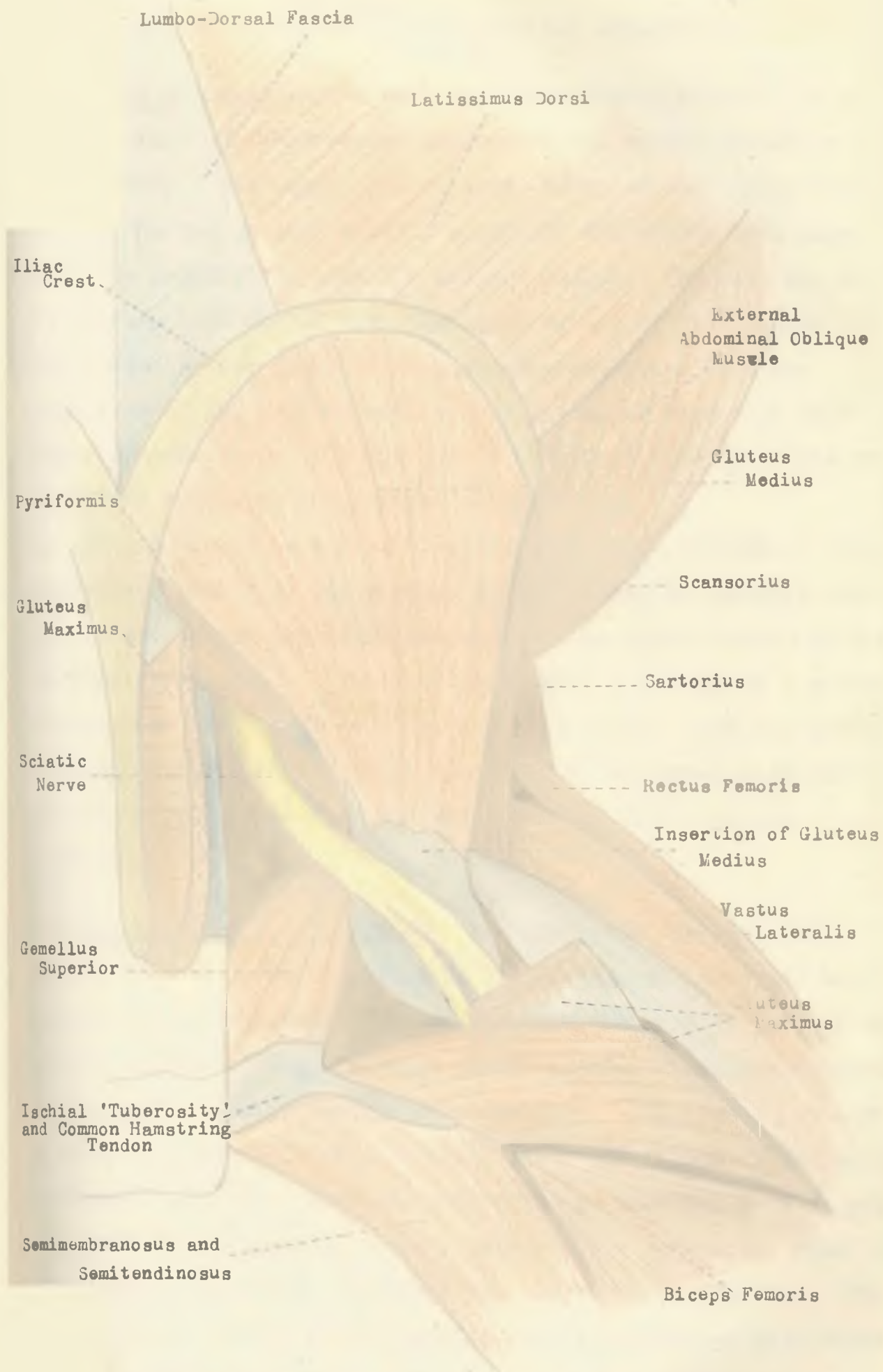


FIGURE 24. ANATOMICAL DRAWING OF THE RIGHT HIP AND THIGH REGION

(Approved: 1/2)

directly above the trochanteric fossa.

The Gemellus superior arises by fleshy fibres from the gluteal surface of the margin of bone directly above the lesser sciatic notch, this portion of bone representing the ischial spine. It gives rise to tendinous fibres which merge with the upper border of the tendon of obturator internus.

The Gemellus inferior also arises by fleshy fibres but from the superior surface of the ischial tuberosity immediately below the lesser sciatic notch. The muscle runs laterally along the lower border of the obturator internus, and soon gives rise to tendinous fibres which merge with the inferior surface of the tendon of insertion of obturator internus. This inferior gemellus was decidedly larger than the superior gemellus. (Figures 26, 27).

Sonntag, Fick, Hepburn and Boyer all describe similarly a weak superior gemellus and a strong inferior gemellus. Hepburn found a certain degree of fusion between the tendon of obturator internus with the tendon of obturator externus. Boyer remarks that the ischial spine is poorly developed in the Orang. This latter author describes what is apparently a continuous origin for the gemelli, from the posterior surface of the ascending ramus of the ischium just above the ischial tuberosity, from the lateral edge of the lesser sciatic notch and from the ischium just inferior to its spine. Hepburn and Primrose do not describe a continuous origin for the gemelli. Hepburn states that in Man, because of his upright posture, the levatores ani muscles have become much more important than in the lower animals, and this is probably accompanied by an increase in the size of the ischial spines.

QUADRATUS FEMORIS: This muscle took origin from the upper portion of the lateral margin of the ischial tuberosity, but as it was considerably fused with the Adductor Magnus, it could not be dissected out satisfactorily.

Sonntag describes this muscle as arising from the outer part of the ischial tuberosity and inserting into two parts, which are attached respectively to the femur behind the lesser trochanter and above the pectineus and to the pectineus and to the back of the great trochanter.

Boyer records this muscle as arising from the medial side of the ischial tuberosity just above the point of attachment of the adductor magnus. It runs laterally to attach to the medial surface of the intertrochanteric line, midway between the two trochanters.

MUSCLES OF THE THIGH.

BICEPS FEMORIS: This muscle is made up of a distinct long head and a short head. The Long head of Biceps arises from the tip of the "lateral limb" of the Common Hamstring Tendon from the ischial tuberosity, from the lateral half of the concave distal border of this Common Tendon, deep to the origin of the Semitendinosus, and from the deep surface of this area of the Common Tendon. (Figure 25)

The belly of the muscle can be easily divided into two portions on the criteria of their insertions and on the direction of their fibres. The smaller upper lateral portion inserts by a tough fibro-muscular sheet into the distal third quarter of the lateral surface of the shaft of the femur, the breadth of the insertion on this infant animal being approximately $3/4$ ", it lying between the lateral intermuscular septum and the origin of the short head of biceps. The larger medial and lower portion has its fibres running almost directly distally. Its upper fibres insert into the lower one quarter of the shaft of the femur on its lateral aspect, the insertion being between the lateral intermuscular septum and the origin of the short head of biceps, it being a millimeter or two distal to the lower border of the insertion of the smaller portion of the long head. The remainder of the larger division of the

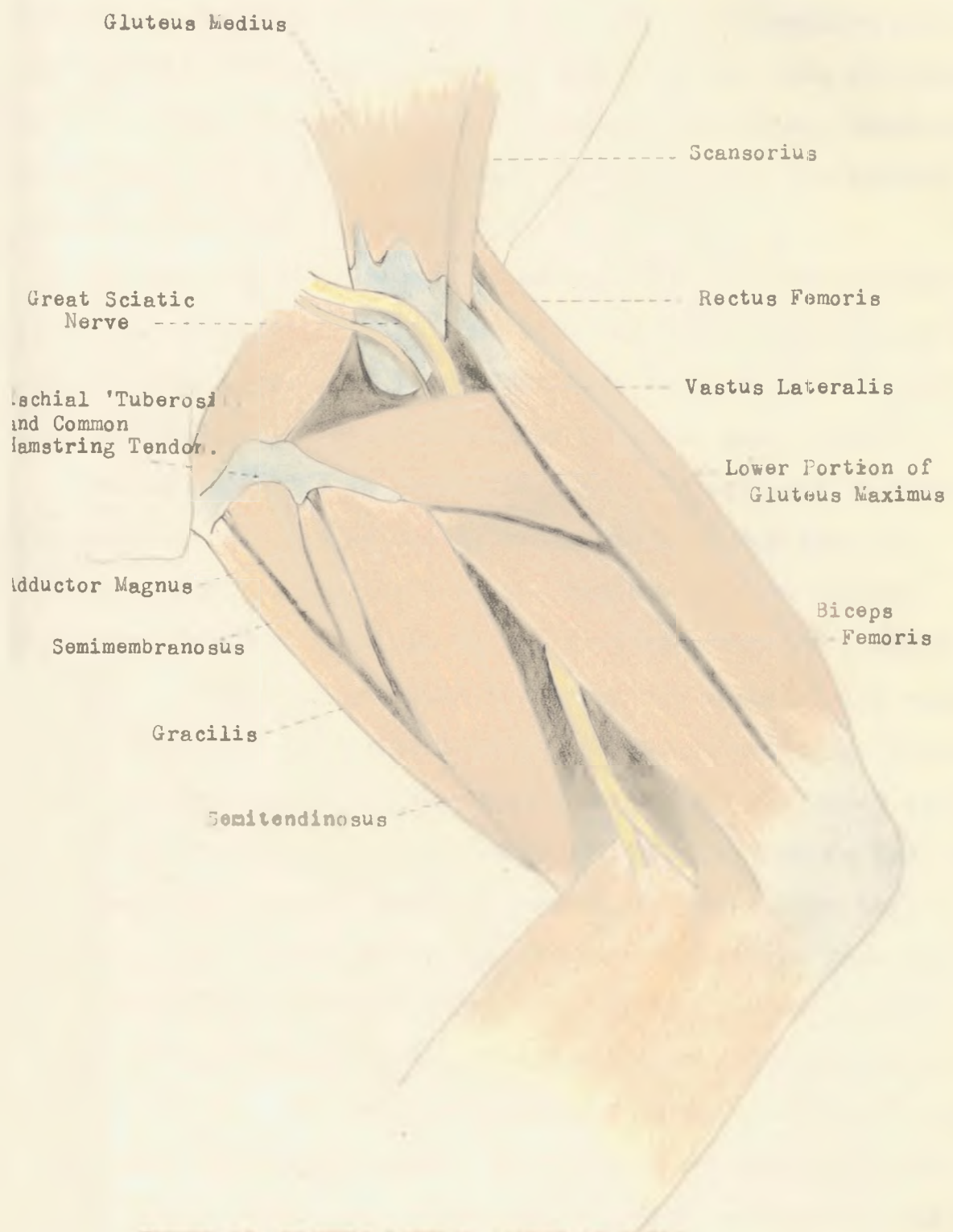


FIGURE 22. POSTERO-LATERAL ASPECT OF THIGH.

(Approx. X 1)

muscle gives rise to a broad tough fibrous sheet which is continuous with the insertion on to the femur, being fused with, and latter appearing as an extension of the lateral intermuscular septum. This sheet inserts from the femur, along the lateral border of the patella, fuses with the lateral border of the ligamentum patellae, into the antero-lateral surface of the tibia and into the lateral surface of the head of the fibula (superficial to the short head of Biceps), and finally into the deep fascia over the lateral portion of the leg. (Figure 28).

The Short Head of Biceps is an entirely separate muscle, having no connections or fusions with any other muscles, not even with the Long head. It is divided into two distant bellies, which are separable from one another in their whole extent.

The smaller head is superficial to the posterior portion of the larger head. It arises by a long thin tendon from the lateral surface of the shaft of the femur below the greater trochanter and just proximal to the bony insertion of Gluteus Maximus. About half-way down the thigh the muscle belly commences. It runs distally, diverging towards its insertion. It inserts partly with the tendon of the deeper portion of the short head of biceps, but by far the greater part of its insertion is into the very dense deep fascia over the lateral surface of the leg.

The larger deeper belly arises by fleshy fibres from the distal two-thirds of the femoral shaft on its postero-lateral aspect, just posterior to the attachment of the lateral intermuscular septum. The muscle inserts by muscular and tendinous fibres into the lateral surface of the head of the fibula and into the deep fascia over the lateral and anterior surfaces of the leg. (Figure 29).

Sountag also finds the long and short heads completely separate from one another. He does not describe any division of the long head and does not find such a large femoral insertion as has been

Gluteus
Medius

Scansorius

Rectus Femoris

Gemellus
Superior

Part of Insertion of
Gluteus Maximus

Ischial
Tuberosity and
Common Hamstring
Tendon

Origin of
Semitendinosus

Adductor
Magnus
(Ischio-femoral
portion)

Vastus
Lateralis

Sciatic Nerve

Semimembranosus

Short Head of Biceps
Femoris

FIGURE 26. POSTERO-LATERAL ASPECT OF THIGH & UPPER LEG.

(Approx. X 1½)

described above. The long head, according to this author, inserts into the outer side of the tuberosity^t of the tibia, and a fibrous expansion connects it to the external femoral condyle. He reports Church as finding the insertion into the capsule of the knee joint. Fick reviews the literature dealing with the long head. He points out that Vrolik, Duvernoy and Huxley regarded it as a piece of the gluteus maximus, whereas Blaschhoff, Heake and Langer showed its true character.

Boyer gives the insertion of the long head as being into the distal two-thirds of the lateral edge of the posterior surface of the femur along the attachment of the vastus externus and into the strong integument-like fascia of the knee and leg region which fastens over the capsule of the knee joint, to the outer condyle of the tibia, the head of the fibula and the proximal one-third of the intermuscular septum between the peroneus longus and the flexor digitorum fibularis. She mentions that this long head on one side of her orang could be divided into two parts by a line 6 cms. from the origin extending to the insertion just above the lateral condyle of the femur.

The origin of the short head is found to be from the distal two-thirds of the femoral shaft parallel and just medial to the femoral insertion of the long head. Its insertion fuses with the tendinous fibres of insertion of the long head, but nevertheless, there is no fleshy union between the two heads.

Scamtag reports the short head as arising from the third quarter of the shaft of the femur on its posterior aspect; it is inserted into the head of the fibula and the fascia over the gastrocnemius. Fick gives a very long origin from the femur, and Hasbourn mentions union with the long head at its insertion.

SEMITENDINOSUS: This large muscle arises by the Common Hamstring Tendon from the ischial tuberosity, being medial to the origin of

Biceps femoris, and lateral and superficial to the origin of Semimembranosus. (Figure 28). It broadens out after passing a little way down the thigh, and develops two strong round tendons in its substance, one tendon being from the superficial edge of the muscle, the other from the deep edge. A tough membranous sheet continues down the muscle belly between these two tendons (which are about of equal size) for the whole distance to their insertions. (Figure 31). The deep tendon inserts proximal to the superficial tendon. The whole inserts into the antero-medial surface of the shaft of the tibia in the whole of its proximal one-third. Its insertion is deep to that of Gracilis. The lower border of the lower tendon has an extensive attachment to the deep fascia over the posterior surface of the leg.

Sonntag describes the insertion of this muscle as being by an extensive aponeurosis into the deep fascia in the upper third of the inner side of the leg. Boyer gives the insertion as being both into the tibia as well as the deep fascia of the leg.

SEMITENDINOSUS: This muscle was found to have a fibrous origin from the medial "limb" and medial half of the concave distal border of the Common Hamstring Tendon from the ischial tuberosity. It is deep to the origin of Semitendinosus. (Figures 28, 29).

After passing distally and medially as a thick, flat belly of muscle it gives rise to a stout tendon which inserts into the medial surface of the head of the Tibia, into the adjacent deep fascia, into the posterior oblique ligament of the knee-joint and finally it extends over the popliteus.

Sonntag records the insertion as being into the internal tuberosity of the tibia, with no expansions into the fascia of the leg. Boyer describes a fleshy rounded attachment to the medial tuberosity of the fibia under-neath the medial collateral ligament of the knee.

SA TORIUS: The muscle was found to arise by a flat membrane from the anterior edge of the iliac bone from the Anterior Superior Iliac Spine to just above the anterior inferior iliac spine, and it appeared to gain some attachment from the adjacent aponeurosis of the abdominal wall and from the fascia covering the Iliacus muscle. Its most proximal part is wedged tightly between the Scansorius and the Iliacus. It inserts by a tough membrane into the lower half of the upper third of the tibia on its antero-medial surface, and into the deep fascia of the leg. (Figure 30).

Montag does not describe such an extensive origin, it being in his animal only from the ilium below the anterior superior spine. The insertion is also not as extensive as the one described above and it tends to be higher up the tibia. He describes it as being into the upper three-quarters of an inch of the inner border of the tibia. Fick describes a more extensive origin from the ilium, and its insertion lower down between the upper and middle thirds of the tibia. Langer states that it is inserted into the deep fascia of the leg. Boyer describes the origin of this muscle as being below the anterior superior iliac spine from the aponeurotic fascia of the abdomen which covers the lateral edge of the iliacus muscle. None of the fibres arise directly from the bone apparently.

PECTUS FEMORIS: The muscle arises by a single continuous head of origin from the Anterior Inferior Iliac Spine and from the bone posterior to this to just above the acetabulum, over its centre. It is wedged in between the Iliacus anteriorly and the Scansorius posteriorly. From this origin the muscle passes distally twisting in such a manner that the portion arising from the inferior spine becomes superficial, while that from the adjacent bone becomes deep. It is a bi-pennate muscle and remains an entirely separate entity down the thigh.

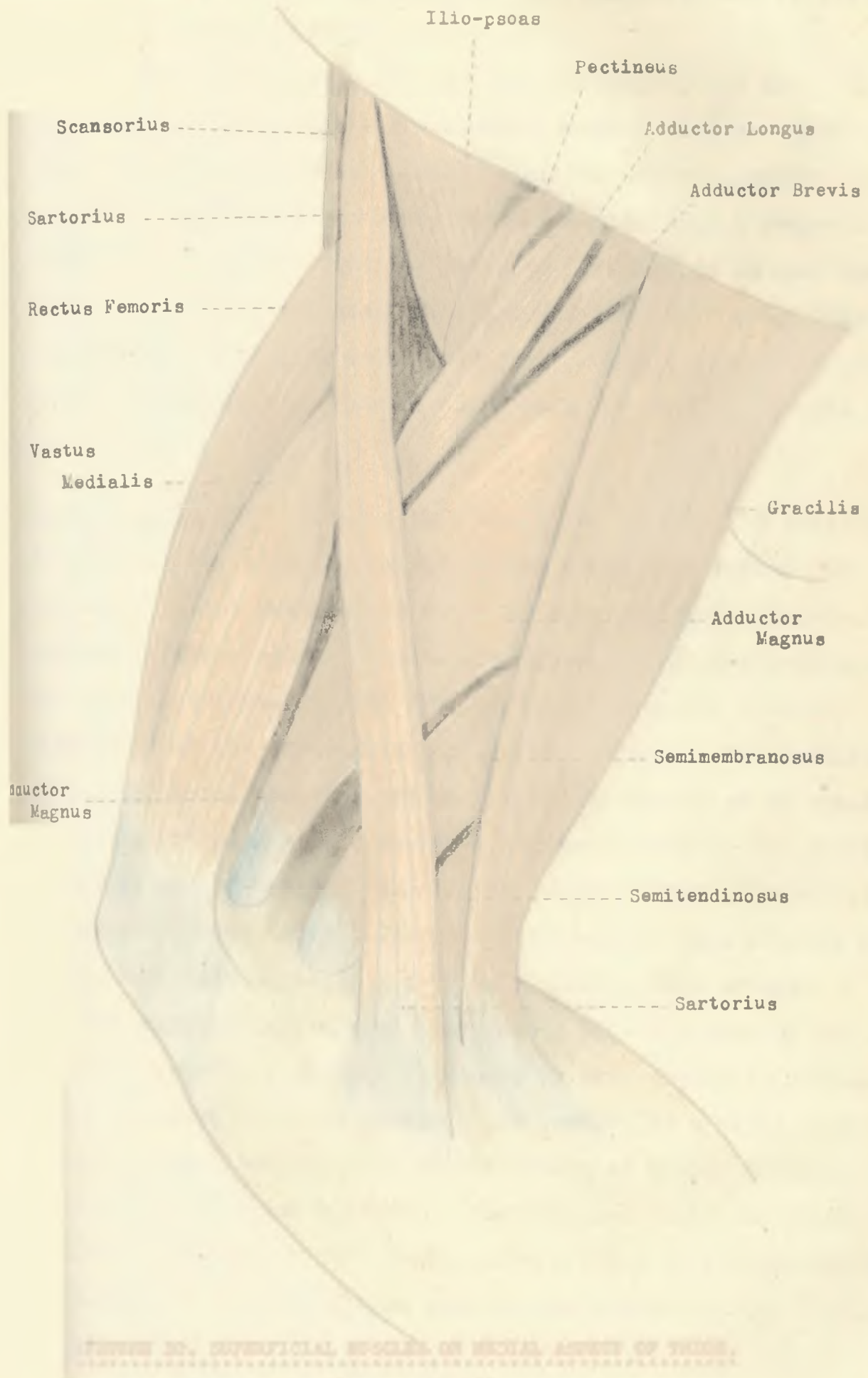


FIGURE 10. SURFICIAL MUSCLES ON MEDIAL ASPECT OF THIGH.

(Approx. X 1½)

It inserts into the superior border of the patella and fuses at the sides with the tendons of Vastus Lateralis and Vastus Medialis. (Figures 28, 29, 30, 31).

Sonntag also finds only one head of origin, and his description of the muscle corresponds closely with the above. Boyer describes a double origin: "from the lateral surface of the ilium at a point 1.7 cm. above the acetabulum from a tubercle corresponding to the anterior inferior iliac spine of man, and also by a reflected tendon posterior and inferior to the lateral attachment". Hepburn found this double origin in all anthropoids except the gibbon. Primrose found only one point of origin in his orang.

VASTUS LATERALIS: This muscle was found to arise by tendinous fibres from the anterior border of the ilium just beneath the origin of Rectus Femoris and from the anterior surface of the ilio-femoral ligament running diagonally downwards and outwards towards the greater trochanter; by a thick tendon from the greater trochanter of the femur directly distal to the insertion of gluteus medius and being almost continuous with the insertion of Scansorius, by fleshy fibres from the proximal three-quarters of the shaft of the femur on its lateral surface, the origin being adjacent to the attachment of the lateral intermuscular septum; and finally from the lateral intermuscular septum to a considerable extent.

The muscle fuses almost immediately with the mass of the Vastus Intermedius, so that it cannot be satisfactorily divided into a separate belly of muscle. It inserts by a broad membranous tendon into the lateral side of the tendon of Rectus Femoris; into the upper and lateral borders of the patella; into the front of the lateral condyle of the ^Tibia, covering and to a large extent replacing the antero lateral part of the capsule of the knee-joint. (Figures 28, 29).

Sonntag gives a much simpler and less extensive origin for this muscle. He found it arising from the outer border of the linea aspera and from the upper third of the septum between itself and the biceps muscle. There does not appear to be the same amount of fusion with the vastus intermedius as is described above.

Boyer mentions the origin of Vastus Externus to have two upward extensions, one on to the lower part of the lateral side of the greater trochanter and the other on to its medial one-third in such a way that these two parts embrace the insertion of the Scansorius.

VASTUS MEDIALIS: The muscle takes origin by fleshy fibres from the distal portion of the trochanteric line, from a line representing the spiral line in the human, from the linea aspera in the upper three-quarters of the shaft of the femur, from the upper part of the medial supracondylar line and from the medial intermuscular septum.

The muscle is a fairly separate entity, fusing with the Vastus Intermedius only in the lower half of the thigh, and then fusion is not complete - the lateral portion of the muscle remaining free. (Figures 30, 31, 32).

It inserts by a very wide flat tendon into the medial border of the tendon of Rectus Femoris, portion of the fibres passing deep to this tendon and fusing with the medial border of the tendon of insertion of Vastus Lateralis; into the upper and medial borders of the patella; into the medial border of ligamentum Patellae; into the head of the tibia, medial to the insertion of the ligamentum patellae; and finally into the deep fascia of the leg.

Sonntag reports this muscle to be fused with the Vastus Intermedius. He gives a less extensive origin than the one described above. He finds it arising from the lower two-thirds of the linea aspera and from the septum between itself and the Adductor Magnus.

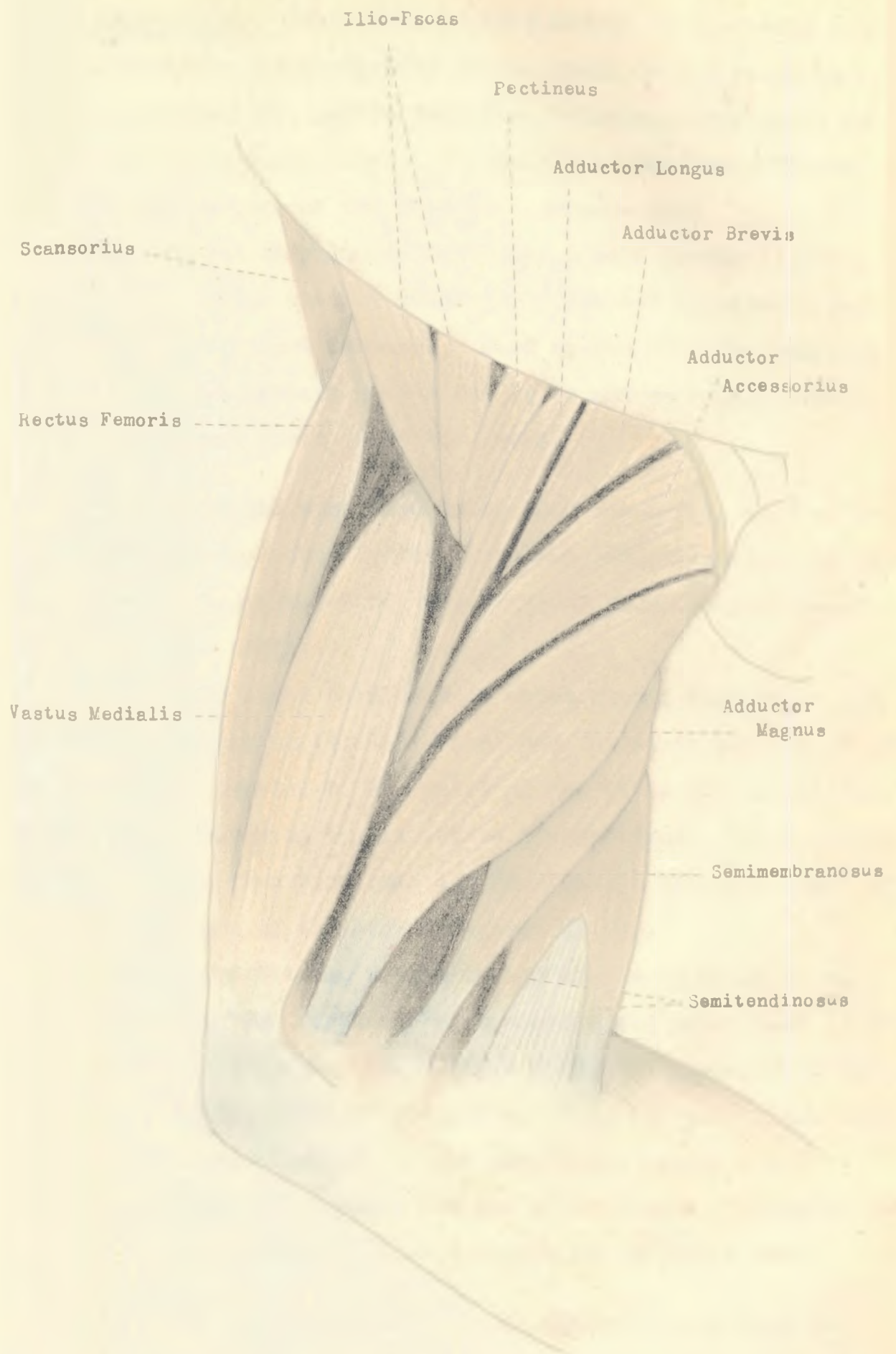


FIGURE 11. MUSCLES OF MEDIAL ASPECT OF RIGHT FEMUR. (ANTERIOR VIEW).
 (Approx. X 3)

VASTUS INTERMEDIUS: The origin of this muscle is by fleshy fibres from the proximal three-quarters of the shaft of the femur on its lateral, anterior and medial surfaces, extending proximally as far as the trochanteric line. It inserts by tendinous fibres into the upper border of the patella. (Figure 32).

Boyer records this muscle as having a very narrow proximal origin. She states that it seems to be crowded in between the other two more distinct muscles. Fick states that the quadriceps is as in Man, but Hepburn points out it is not so easily separable into its component parts as in the human.

GRACILIS: The origin was found to be from the medial half of the upper border of the Pubic Crest; from the lateral portion of the whole of the Symphysis Pubis; and from the anterior portion of the ischio-pubic ramus.

It is a very large bulky muscle which passes down the medial border of the thigh to its insertion into the upper portion of the proximal second quarter of the shaft of the tibia on its antero-medial surface, deep to the insertion of Sartorius. It also has a very extensive insertion into the deep fascia over the whole of the medial surface of the leg. (Figures 28, 30.)

Schntag describes the origin of the muscle as being by an aponeurosis from "the front of the symphysis and upper part of the ascending ramus of the pubis". Boyer finds the gracilis arising from the horizontal ramus of the pubis; from the body close to the symphysis and from a portion of the descending ramus, - a description resembling closely the one given above. Primrose and Fick state that the origin did not extend to the pubic rami.

PECTINEUS: This muscle takes origin by fleshy fibres from the horizontal ramus of the pubis, lateral to the pubic tubercle, and from the fascia covering it. The muscle passes downwards, back-

wards and laterally in close association with the Adductor Longus. It inserts into the femur below the lesser trochanter in the line directed from the lesser trochanter towards the upper part of the linea aspera. (Figures 30, 31, 32).

Hepburn states that there is close association between the adductor longus and the pectineus in the gorilla and orang, and that the pectineus sometimes takes up a part of the longus.

ADDUCTOR ACCESSORIUS: The origin of this muscle is from the medial portion of the pubic crest and from the lateral portion of the whole of the symphysis pubis. It lies immediately deep to the Gracilis and arises adjacent to it. (Figures 31, 32).

It inserts half-way down the thigh by aponeurosis into the linea aspera, being in close opposition and actually inserting with the Adductor Magnus. The belly of this muscle covers the medial half of the Adductor Brevis Muscle, the Obturator Externus Muscle (a large amount of fat separating them) and the upper portion of Adductor Magnus Muscle.

Boyer describes this muscle^s as being wider and stronger than either the longus or brevis. She gives an origin and insertion resembling closely the above description. The muscle, she states, could be described as part of either the Adductor brevis or the Adductor magnus. Primrose includes it as part of the Adductor magnus.

ADDUCTOR BREVIS: This muscle was found to arise by fleshy fibres from the pubic bone on its outer surface, extending from the symphysis pubis to just deep to the origin of the Adductor Longus. Its origin lies deep to the origins of Gracilis, Adductor Accessorius and Adductor Longus. Deep to it lies the Obturator externus. (Figures 30, 31, 32).

It inserts into the posterior surface of the upper one-quarter

of the shaft of the femur, between the insertion of the pectineus medially and that of Adductor Magnus laterally.

Sonntag gives a similar description of the muscle. Boyer mentions that the muscle can be separated into two parts which fuse again into a single muscle. Hepburn also found this muscle in the orang to be partially separated into two divisions.

ADDUCTOR LONGUS: This muscle was found to take origin from the pubic crest, being just medial to the pectineus origin.

It inserted by tendinous into the posterior surface of the shaft of the femur in its lower third quarter, medial to the insertion of Adductor Brevis. (Figures 30, 31, 32).

Sonntag describes the muscle very much the same as the above. Pick states that it arises in the adult from an ilio-pectineal tubercle.

ADDUCTOR MAGNUS: The origin was found to be by fleshy fibres from the whole of the ischio-pubic ramus extending from the lower part of the symphysis pubis right up to the ischial tuberosity. It also gains some attachment from the medial border of the common tendon of the hamstring muscles. (Figures 28, 29, 30, 31, 32).

The muscle inserts into the posterior surface of the whole of the shaft of the femur in a somewhat diagonal manner, the uppermost fibres which come from the lower part of the symphysis pubis inserting just beneath the posterior and distal portion of the greater trochanter of the femur, while the fibres arising near the ischial tuberosity insert into the Adductor tubercle on the medial epicondyle of the femur. The remainder of the muscle fibres insert between these two extremes. The ischio-condylar portion of the muscle separates off as a quite distinct belly in the distal half of the thigh.

Sonntag finds a more extensive origin, as in his animal the

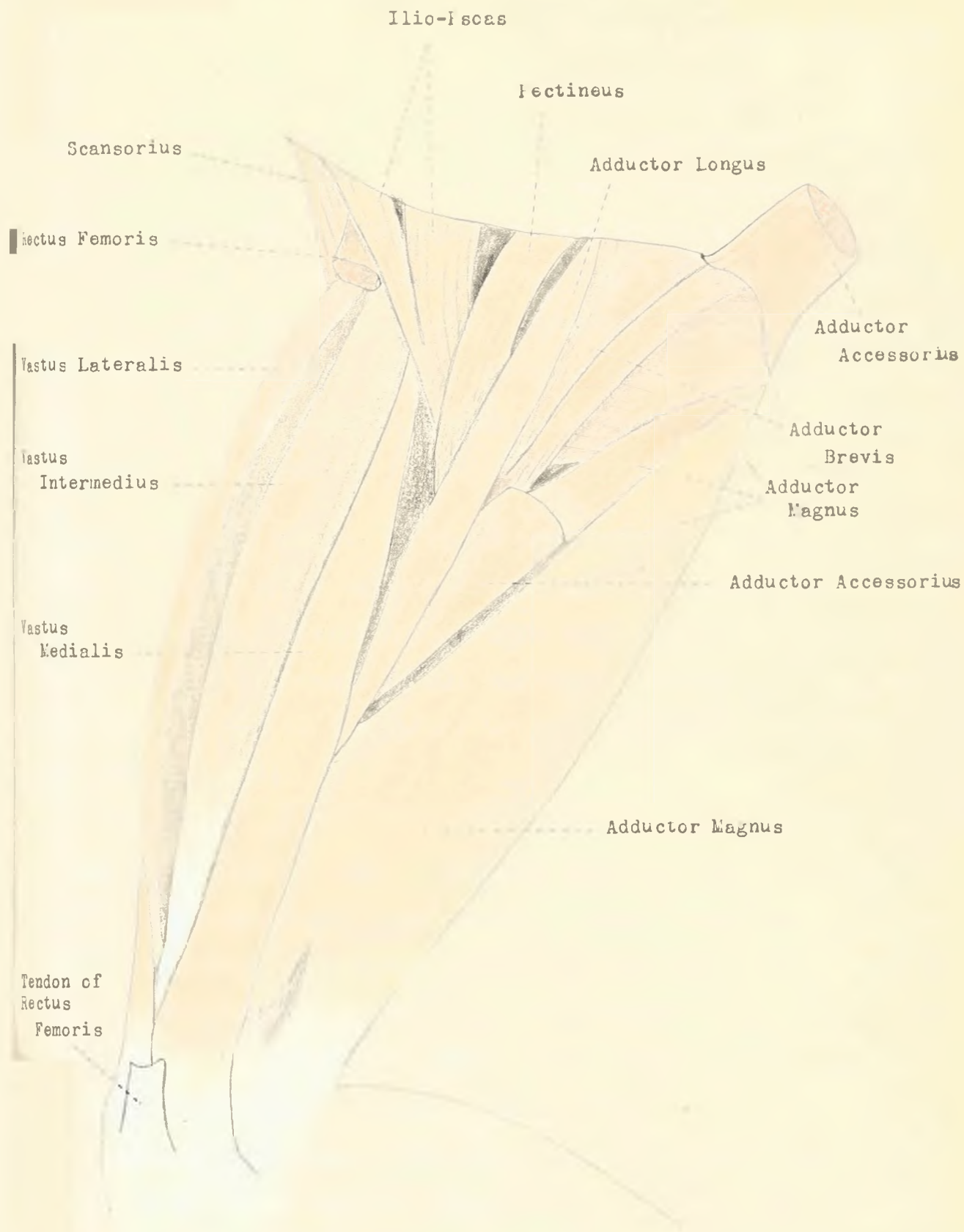


Fig. 1. The right thigh, showing the muscles and tendons.

the muscle arose from the entire length of the symphysis pubis - not just from the posterior part as described above. Boyer, on the other hand, does not find the origin extending as far forwards as the symphysis, but gives the attachment as from the lower portion of the inferior ramus of the pubic bone, from the inferior ramus of the ischium, and from a portion of the ischial tuberosity.

Sonntag finds the muscle divided into two parts, and Beddard also finds this division. Boyer describes the muscle as being in three fasciculi, approximately the same as in Man. Hepburn found that among the anthropoids the adductor magnus of the orang was the most like that of man.

ILIO-Psoas: The portion of the muscle mass representing the Psoas Major arises from the antero-lateral surface of the lower half of the last thoracic vertebrae and from the antero-lateral surfaces and transverse processes of all the lumbar vertebrae. The fibres pass distally and at the pelvic brim it fuses with the fibres of the Iliacus muscle.

The Iliacus muscle arises from the whole of the pelvic surface of the iliac wing. This is comparatively a large area and it gives rise to a comparatively large muscle. The fibres converge distally and on the medial side become fused with the psoas mass. The whole passes into the thigh as the ilio-psoas column, to come to insert into the lesser trochanter of the femur and for a little distance below this. (Figures 30, 31, 32).

Boyer gives a similar description of the muscle, but finds the origin of the psoas major to be only from the antero-lateral surfaces of the four lumbar vertebrae and their transverse processes. Bryce states that the psoas magnus and iliacus occur in lower animals as separate muscles. Sonntag states that the psoas major arises from the last dorsal and all the lumbar vertebrae.

OBTURATOR EXTERNUS: The origin was from the margin of the obturator foramen formed by the superior ramus of the pubis, the body of the pubis, the inferior ramus of the pubis, and the anterior part of the lower ramus of the ischium, together with the origin from the obturator membrane. The muscle converges laterally to pass in a groove just posterior to the Acetabulum, giving rise to a tendon which inserts into the trochanteric fossa of the greater trochanter of the femur. The tendon is in very close association with the tendon of the obturator internus, which inserts just above it.

Sonntag states that he found the origin of this muscle much the same in the orang as it is in man. Boyer describes the origin as being from the inferior and superior ram of the pubis and immediately lateral to the proximal attachments of the adductores brevis, accessorius and magnus, and from the medial one-half of the obturator membrane. She indicates that the trochanteric fossa is used for the insertion of the tendon of obturator internus as well as for the insertion of the tendon of obturator externus.

MUSCLES OF THE LEG AND DORSUM OF FOOT.

TIBIALIS ANTERIOR: This muscle was found to arise by fleshy fibres from the lateral condyle of the tibia; from the proximal half of the anterior surface of the shaft of the tibia; from the proximal two-thirds of the lateral surface of the tibia; from the proximal and medial portion of the interosseous membrane in the proximal half of the leg, in a triangular fashion; and finally it also gains attachment from the dense deep fascia, especially in its proximal portion where the extensions of the insertions of Biceps femoris, Semitendinosus and Gracilis overlie it. (Figures 33, 34, 36).

There is no septum worthy of note between this muscle and the Extensor Digitorum longus. The muscle belly runs distally and medially, and after passing under the Extensor Retinaculum it gives rise to two distinct tendons, the larger posterior one inserting into the medial surface of the medial cuneiform bone, and the smaller anterior one inserting into the medial surface of the base of the first metatarsal. (Figures 35, 36).

Sonntag describes this muscle as actually splitting into two bellies, each of which gives rise to a tendon. The insertions are into the medial aspect of proximal end of the first metatarsal, and the other is into the plantar aspect of the internal cuneiform and joint capsule. He does not mention the muscle as taking origin from the interosseous membrane or from the deep fascia and tendinous expansions of the leg; Boyer, on the other hand does mention these. This latter author found the muscle belly to split into two parts only in the most part of the leg.

EXTENSOR HALLUCIS LONGUS: The muscle takes origin by fleshy fibres from the middle one-third of the antero-medial surface of the shaft of the fibula, medial to the origin of Extensor Digitorum longus, and from the adjacent portion of the interosseous

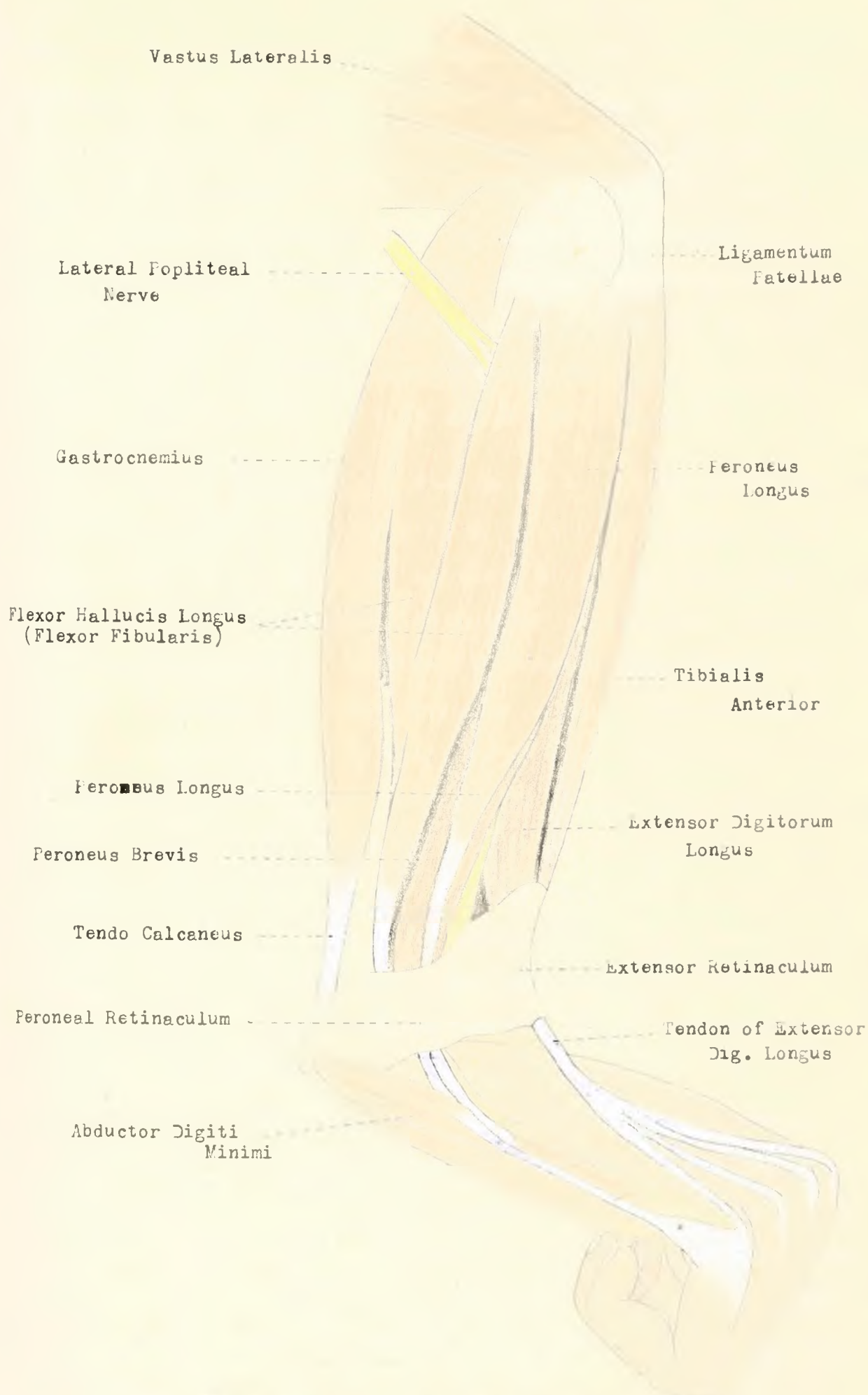


FIGURE 10. LATERAL VIEW OF THE RIGHT LEG

membrane. It passes distally and slightly medially under the Extensor Retinaculum and gives rise to a small tendon, passing anterior to the tendons of Tibialis Anterior, which inserts into the distal phalanx of the Hallux. (Figures 34, 35, 36).

Soontag found a much more extensive origin for this muscle. He describes it as coming from the upper three-quarters of the inner surface of the shaft of the fibula. Boyer gives a small and fairly weak origin for this muscle, - from the anterior surface of the interosseous membrane at the central region of the leg. She mentions no bony origin for this muscle.

EXTENSOR DIGITORUM LONGUS: The muscle arises by fleshy fibres from the antero-lateral surface of the lateral condyle of the head of the tibia; from the anterior surface of the head of the fibula; from the antero-medial surface of the shaft of the fibula in its proximal half; and from the dense fibrous sheet lying between this muscle and the Peroneus Longus. (Figures 33, 34).

The muscle belly runs directly distally converging as it does so, and under the Extensor Retinaculum it gives rise to a strong round tendon, which, on the dorsum of the foot, splits into three portions, each of which goes to supply one of the lateral three digits of the foot. The most medial band, which runs on to the third digit, gives off a small slip medially about half-way down the foot, this running on to the second toe and acting as an extensor tendon for this digit. (Figure 35).

All these extensor tendons are very wide flat bands which spread out for a considerable extent over the metatarso-phalangeal joints. Here they receive the tendons of the lumbricales and those of the interossei. After extending distally as broad fibrous sheets which cover the dorsal surfaces of the phalanges, they insert into the base of the distal phalanx of the lateral four digits.

Sonntag finds the fibular origin to be more extensive, describing it as being from the upper two-thirds of the inner surface of the shaft of the fibula. Boyer records the origin of the muscle as being from the proximal three-fourths of the inter-muscular septum which separates the peronei group from this muscle, from the lateral tuberosity of the tibia and from the inner portion of the head of the fibula.

EXTENSOR DIGITORUM BREVIS: The muscle is divided into two separate and distinct parts; - that medial portion supplying the Hallux, which may appropriately be called the Extensor Hallucis Brevis, and the remainder of the muscle which is lateral to this. This latter portion may really be called the Extensor Digitorum Brevis since it supplies the middle three digits. (Figures 34, 35).

The Extensor Hallucis Brevis arises by fleshy fibres from the upper portion of the lateral surface of the anterior half of the Calcaneum; from the medial surface of the tough fibrous sheath of the Extensor Digitorum Longus tendon; and finally from the inferior border of the Extensor Retinaculum, medial to this Extensor Digitorum Longus tendon. The muscle-belly passes almost directly medially and gives rise over the first carpo-metatarsal joint to a strong flat tendon. This structure runs on the dorsum of the first metatarsal and inserts into the base of the phalanx of the Hallux on its dorsal surface.

The large lateral mass, supplying the middle three digits, can be divided off into two laminae, - a small superficial one and a large deep one. The superficial lamina arises by musculo-tendinous fibres from the upper half of the lateral surface of the anterior two-thirds of the Calcaneum and from the lateral portion of the Calcaneo-Cuboid ligament. It divides into three well defined bellies, a large medial one and two smaller lateral ones. Each of these gives rise to a long slender tendon which inserts into

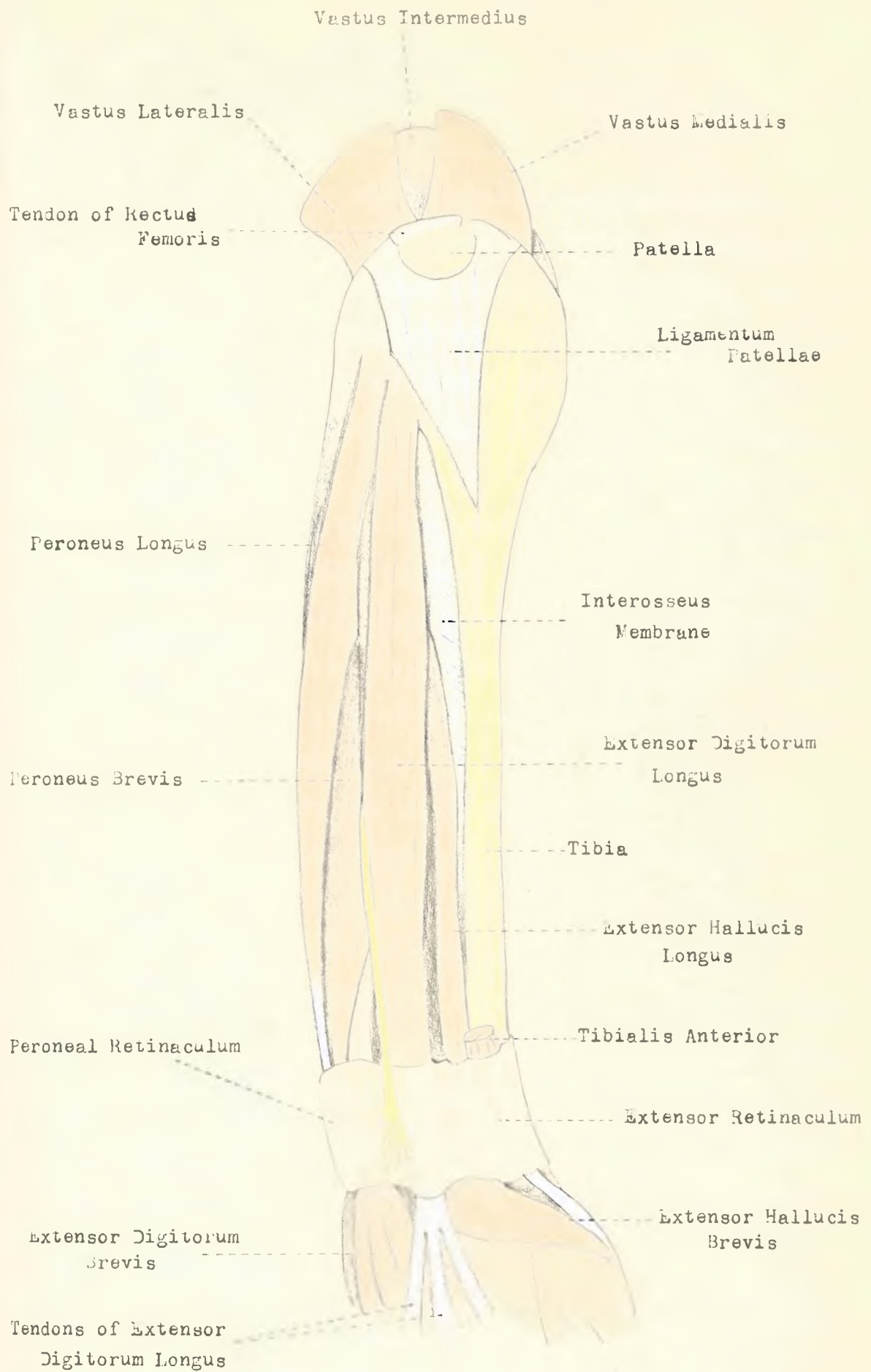


FIGURE 24. ANTERIOR VIEW OF THE RIGHT LEG, PATELLA REMOVED. (APPROX. 1/2)

the lateral half of the Extensor tendon of the Extensor Digitorum longus muscle on the dorsum of the digit concerned. The medial belly supplies digit two, the middle belly digit three, and the lateral belly digit four.

The deep lamina arises by musculo-tendinous fibres from the whole dorsal surface of the Cuboid and lateral cuneiform; from the bases of the third, fourth and fifth metatarsals and the various ligaments and capsules joining these bones; from the dorsal surface of the capsule and ligament of the calcaneo-cuboid joint; and finally from the medial aspect of the tendon of Peroneus Brevis just before it inserts. It runs distally as a large flat sheet of muscle, which, on reaching the level of the distal quarter of the shafts of the metatarsals, divides into three bellies, the lateral one being the smallest. Each gives rise to a broad tendon which fuses with the corresponding tendon of the superficial lamina on its deep surface, just before it inserts into the main extensor sheet of the digit concerned.

The fifth digit has no short extensor.

Sonntag reports this muscle as arising from the calcaneum by four bellies which are separated by septa. He mentions no further origin and does not indicate that he found the muscle divisible into two laminae. Boyer, likewise, describes the muscle as consisting of four distinct spindle-shaped muscles, each of which arises immediately as a separate portion. The origins are from the superior and lateral surface of the calcaneum, in close relation to the tendons of the peroneus longus and peroneus brevis, inferior to the fibular malleolus.

PERONEUS LONGUS: The origin is from the antero-lateral and lateral surfaces of the head of the fibula, of the proximal half of the shaft of the fibula; from the intermuscular septum; and from the very dense fascia overlying it. (Figures 33, 34, 39).

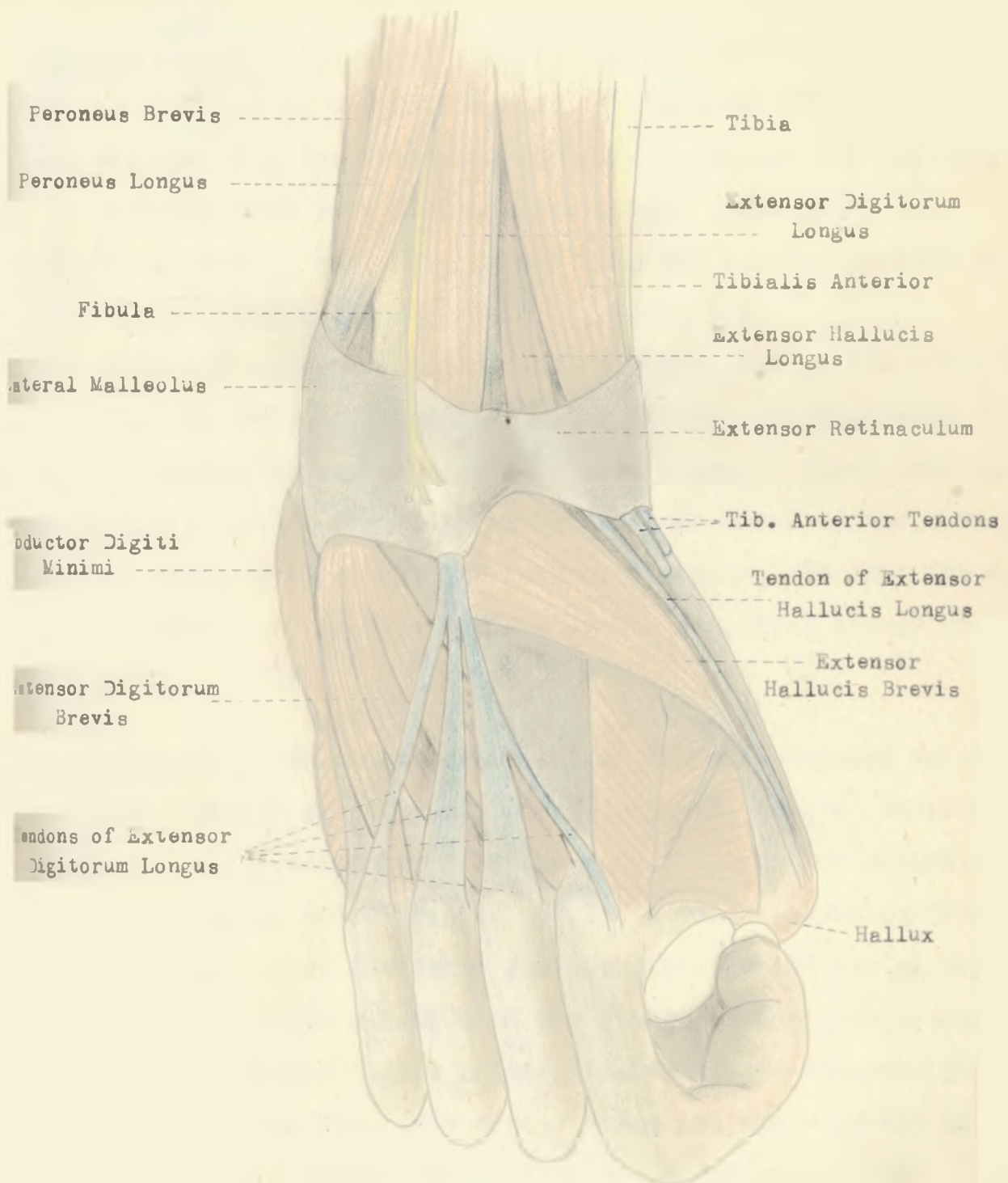


FIGURE 36. DEEP MUSCLES AND TENDONS OF ANKLE AND FOOT. (APPROX. 2 1/2)

The tendon passes down to the lateral edge of the foot, grooves the Cuboid as it passes round into the sole of the foot which it crosses, and inserts into the lateral surface of the base of the first metatarsal. (Figures 46, 48).

Sonntag describes a muscle which resembles closely the one above. Similarly Boyer reports a muscle resembling in origin and insertion the above muscle.

PERONEUS BREVIS: The muscle arises from the lateral and antero-lateral surfaces of the middle half of the shaft of the fibula and from the adjacent intermuscular septums. (Figures 33, 34, 39).

It gives rise to a tendon which passes round under the lateral malleolus, coming to insert into the lateral surface of the base of the fifth metatarsal bone. (Figure 45).

Sonntag's muscle resembles this closely, but he describes the tendon on one side dividing into three parts. Hepburn also found that the tendon on one side divided into slips. Boyer describes the origin as being from only the middle one-third of the lateral surface of the fibula, the intermuscular septum, and from the overlying fascia. No mention is made of the inserting tendon dividing into slips.

GASTROCNEMIUS: The muscle consists of two well-defined bellies, the larger medial one slightly overlapping the smaller lateral head. The Medial belly arises by a tendinous and a muscular origin. The medial portion of the origin is solely by tendon, arising from the popliteal surface of the femur just proximal to the medial condyle. It fuses to a slight extent with the tendon of the ischio-condylar part of the Adductor Magnus which attaches to the Adductor Tubercle. The muscle arising from this tendon forms the whole of the superficial portion of the medial belly of Gastrocnemius. The remainder of the origin of the medial belly is by fleshy fibres from

the popliteal surface of the femur directly above and slightly lateral to the attachments of the tendinous portion. It also has some attachment to the posterior ligament and capsule of the knee joint. This fleshy portion gives rise to a broad flat tendon in the upper one-third of the leg which forms the deep surface of the medial belly of gastrocnemius, and it is with this structure that the tendon of Soleus fuses.

The Lateral belly arises, together with the femoral head of the Flexor Fibularis muscle, by tendinous fibres from the popliteal surface of the femur just above the lateral condyle, and extending on to the adjacent lateral surface of the distal portion of the femur. It also has a very firm attachment to the knee joint, so much so that it apparently forms that portion of the capsule. The fibres are closely adherent to those of the femoral origin of the Flexor Fibularis, being superficial and slightly medial to these. The lateral belly runs distally and medially into the lateral edge of the tendon on the deep surface of the Medial head of the Gastrocnemius. This combined tendon, having incorporated the tendon of the Soleus muscle, becomes the tendo Achilles, which inserts into the middle of the posterior surface of the calcaneum. (Figures 33, 36, 37).

Sonntag does not mention the lateral head of the muscle as arising in conjunction with the long head of the flexor fibularis muscle, but Boyer describes such a condition. The former author reports the lateral belly to be thinner but wider than the medial belly, while the latter author states that she found the two bellies equally developed.

SOLEUS: The muscle arises from the posterior surface of the head of the fibula, and the posterior surface of the superior tibio-fibular joint. At its origin the muscle is wedged in between the lower border of the Popliteus and the medial border of the Flexor

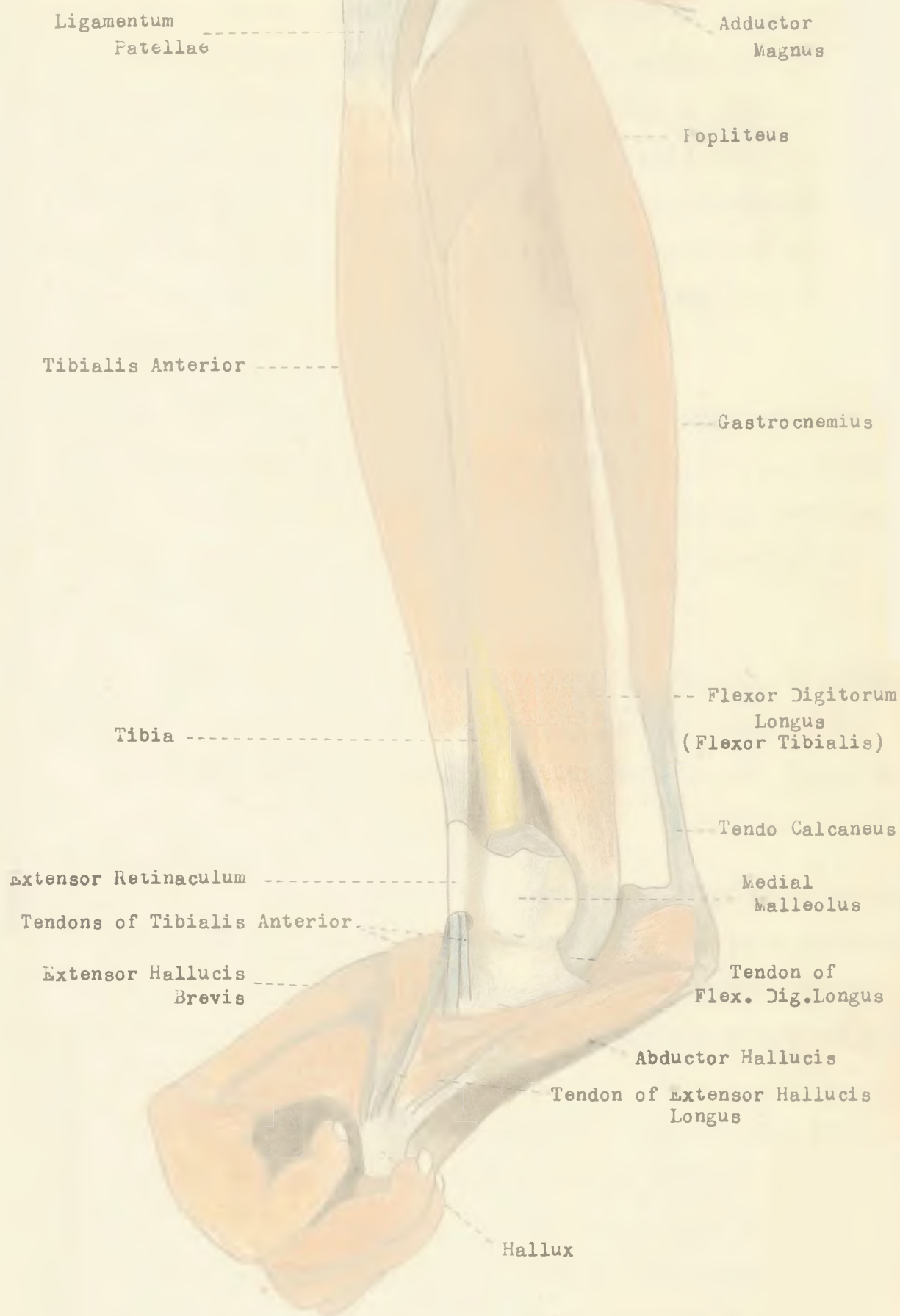


FIGURE 36. MEDIAL ASPECT OF RIGHT LEG.
 (Anatom. X 1/2)

Fibularis. The belly passes medially then bends downwards, swelling out distally. It is a very small muscle and is completely covered by the medial belly of the Gastrocnemius. It gives rise to a thin flat tendon which fuses with the tendon of the medial belly of the Gastrocnemius to form the tendo Achilles. (Figure 37).

No tibial attachments are found by Sonntag or Boyer. The latter author, however, describes a large muscle, stating that this muscle broadens to the same width as the gastrocnemius and remains practically the same size until it becomes entirely tendinous, that is, apparently lay down in the leg, just before its attachment to the calcaneum.

PERONEUS TERTIUS: This muscle was not found. This absence appears to be constant for the orang, and indeed, for the other anthropoids and lower apes. Boyer states that though its development is often correlated with the erect posture in man, it is found in lower mammals.

PLANTARIS: This muscle was absent. Sonntag does not describe it, and Boyer states that the muscle could not be found on her orang. Primrose quotes one case on record having been found in the orang.

OPRITRUS: This was found to be a large thick triangular muscle situated deeply on the posterior surface of the leg just below the knee joint. (Figures 36, 37, 38, 39). The apex is the origin of the muscle and this can be divided into two heads - a superficial and a deep head.

The superficial head arises by tendinous fibres from the inferior portion of the lateral surface of the lateral epicondyle of the femur, slightly above and even confluent with the capsule of the knee joint, lying deep to the lateral collateral ligament of the knee joint. These fibres of origin fuse to a great extent

with the capsule of the joint.

The deep head, which comprises the major portion of the origin, arises from the distal border of a small triangularly shaped piece of fibro-cartilage situated within the capsule of the joint itself. This cartilage is very firmly attached to a conspicuous groove on the lateral surface of the lateral condyle of the femur by means of a thick fibrous band, the lower border of which sends a considerable slip down to the head of the fibula. The deep surface of the fibro-cartilage shows two well-marked articulating surfaces - a large lower one for the lateral portion of the head of the tibia, and a small upper one for the back of the lateral meniscus of the knee-joint.

The fibres arising from this deep head pass downwards and backwards, pierce the capsule of the knee-joint, and then fuse with the deep surface of the superficial head of the muscle. The whole proceeds medially and distally, diverging to form a thick fleshy belly which inserts into the proximal two-fifths of the postero-medial surface of the shaft of the tibia.

Sonntag states that he found no trace of a division into two parts. The origin of the muscle is apparently entirely extra-capsular, since it is described as being simply by a thin strong tendon from the lateral epicondyle of the femur.

Boyer does not find the muscle divided into superficial and deep heads, but the origin given resembles the one described above. It is by a strong narrow tendon from the tuberosity of the lateral condyle of the femur behind the lateral collateral ligament of the knee joint and below the common attachment of the gastrocnemius and flexor digitorum fibularis. This tendon passes over the lateral condyle of the tibia at which point a sesamoid bone is embedded in it. There are no indications in the description that this is intracapsular.

Origin of
Medial Head of
Gastrocnemius

Origin of the
Lateral Head of
Gastrocnemius

Flexor Hallucis Longus
(Flexor Fibularis)

Popliteus

Lateral Popliteal
Nerve

Medial Popliteal
Nerve

Soleus

Flexor Digitorum Longus
(Flexor Tibialis)

Flexor Hallucis Longus
(Flexor Fibularis)

Peroneus Longus Tendon

Medial Malleolus

Peroneus Brevis

Tendo Calcaneus

Lateral Malleolus



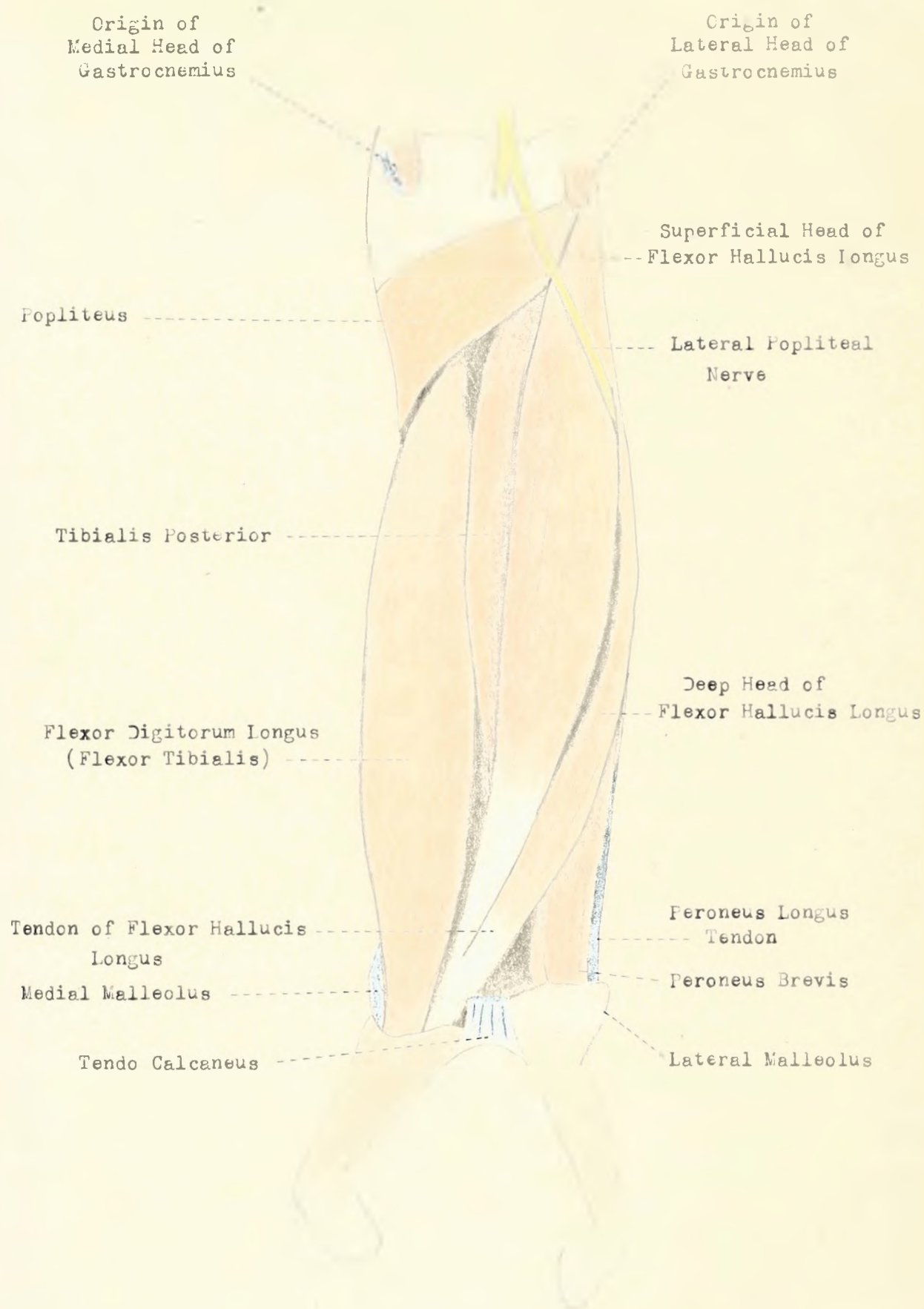
FLEXOR DIGITORUM LONGUS: This muscle, also known as the Flexor Tibialis, was found to take origin from the posterior surface of the proximal three-quarters of the shaft of the tibia, excepting that area of the bone used for the insertion of the popliteus. It also gains origin from the dense aponeurosis over the Tibialis posterior muscle, and by this means gains indirect attachment to the medial surface of the upper half of the fibula. The distal part of the muscle arises from the interosseous membrane distal to the origin of the Tibialis posterior. (Figures 36, 37, 38).

It gives rise to a powerful tendon which passes round the medial malleolus between the tendons of tibialis posterior and that of flexor fibularis. In the sole of the foot it splits into two tendons, the medial one inserting into the base of the distal phalanx of the second digit, the lateral inserting into the base of the distal phalanx of the fifth digit, - after it has given off a small slip high up which fuses with the tendon of Flexor Digitorum Brevis inserting into the fourth digit. (Figure 45).

Sonntag describes this muscle as arising from the upper two-thirds of the inner surface of the shaft of the tibia alone, mentioning no other attachments. He finds the tendons are inserted into the second, fourth and fifth toes, the tendon to the fifth toe being slender. He states that there is individual variation in the disposition of the tendons of the flexor fibularis, flexor tibialis, and flexor digitorum brevis. Hapburn and Pick give the insertion as the second and the fifth digits.

Boyer finds the muscle arising from a very narrow line of attachment on the inner anterior border of the proximal two-thirds of the fibula, but its strongest attachment is to the antero-lateral surface of the proximal three-fourths of the tibia.

The tendon of insertion is described as splitting into three portions the medial tendon inserting into the second digit, the lateral tendon



inserting into the fifth digit, and the middle tendon fusing with the tendon of the flexor digitorum brevis which goes to the fourth toe. Thus Boyer's muscle corresponds very closely with the muscle described above.

LUMBRICALES: Four lumbrical muscles were found in the foot. (Figures 45, 46). The first lumbrical arises from the plantar and medial surfaces of the deep flexor tendon to the second digit, (i.e. the medial tendon of the flexor digitorum longus). It passes forwards as a thin column of muscle which gives rise to a small flat tendon. This inserts into the medial border of the extensor tendon on the dorsum of the second digit.

The second lumbrical arises by two heads: one from the plantar and lateral surface of the deep flexor tendon to the second digit, the other from the plantar surface of the tendon of flexor fibularis to the third digit. The origin extends much further backwards along the tendon than the first lumbrical. The two heads fuse and give rise to a tendon which inserts like the others into the extensor sheet on the dorsum of the third digit.

The third lumbrical arises from the plantar and medial surfaces of the deep flexor tendon to the fourth digit, its origin extending up the tendon as far as the bifurcation of the flexor fibularis tendon. In size it equals the second lumbrical and is about twice the size of the first or fourth lumbricales. Its tendon inserts into the medial border of the extensor tendon to the fourth digit. Boyer describes a double head of origin for this muscle.

The fourth lumbrical arises from the medial surface of the deep flexor tendon to the fifth digit, its origin extending up as far as the base of the fourth metatarsal. Its tendon passes round the medial side of the fifth metatarso-phalangeal joint and inserts into the medial border of the extensor tendon of the fifth digit.

Boyer and Sonntag describe similar arrangements for the lumbricals. Primrose found the fourth lumbrical to arise by two heads.

FLEXOR HALUCIS LONGUS: This large muscle, also known as the Flexor Fibularis, was found to arise by two heads, a superficial and a deep. (Figures 33, 37, 38).

The superficial, long, or femoral head arises by tendinous fibres from that area of the distal end of the femur where popliteal surface and lateral surface merge, just proximal to the condyle, and being deep and somewhat lateral to the origin of the lateral belly of Gastrocnemius, fusing with this structure to some extent. It also has attachment to the postero-lateral portion of the capsule of the knee joint, actually appearing to replace part of the capsule. The thick and elongated belly covers most of the posterior surface of the deep belly, and eventually gives rise to a flat, thin, wide tendon which fuses with a dense aponeurosis on the distal portion of the deep head.

The deep head arises by fleshy fibres from the posterior and lateral surface of the head of the fibula; from the proximal two-thirds of the shaft of the fibula on its posterior surface; and from the interosseous membrane, adjacent to the distal portion of the fibular attachment. The muscle gains further origin from the posterior part of the lateral ligament of the knee-joint, from the intermuscular septum separating it from the peronei muscles, and finally the lateral surface of the muscle gains considerable attachment from the extension of the insertion of Biceps femoris and from the deep fascia.

The distal part of the muscle gives rise to a strong tendon which passes round the medial malleolus, medial to the flexor digitorum longus. In the sole of the foot it splits into two tendons which attach to the base of the distal phalanx of the third

and fourth digits. (Figure 46).

Sonntag similarly describes two heads of origin for this muscle, but he does not find such an extensive origin for the deep head, this part springing from the head and only the upper half of the shaft of the fibula. Hapburn and Pick apparently give more limited origin to the muscle than even Sonntag. Insertion agrees with the above description, there being no tendon to the hallux.

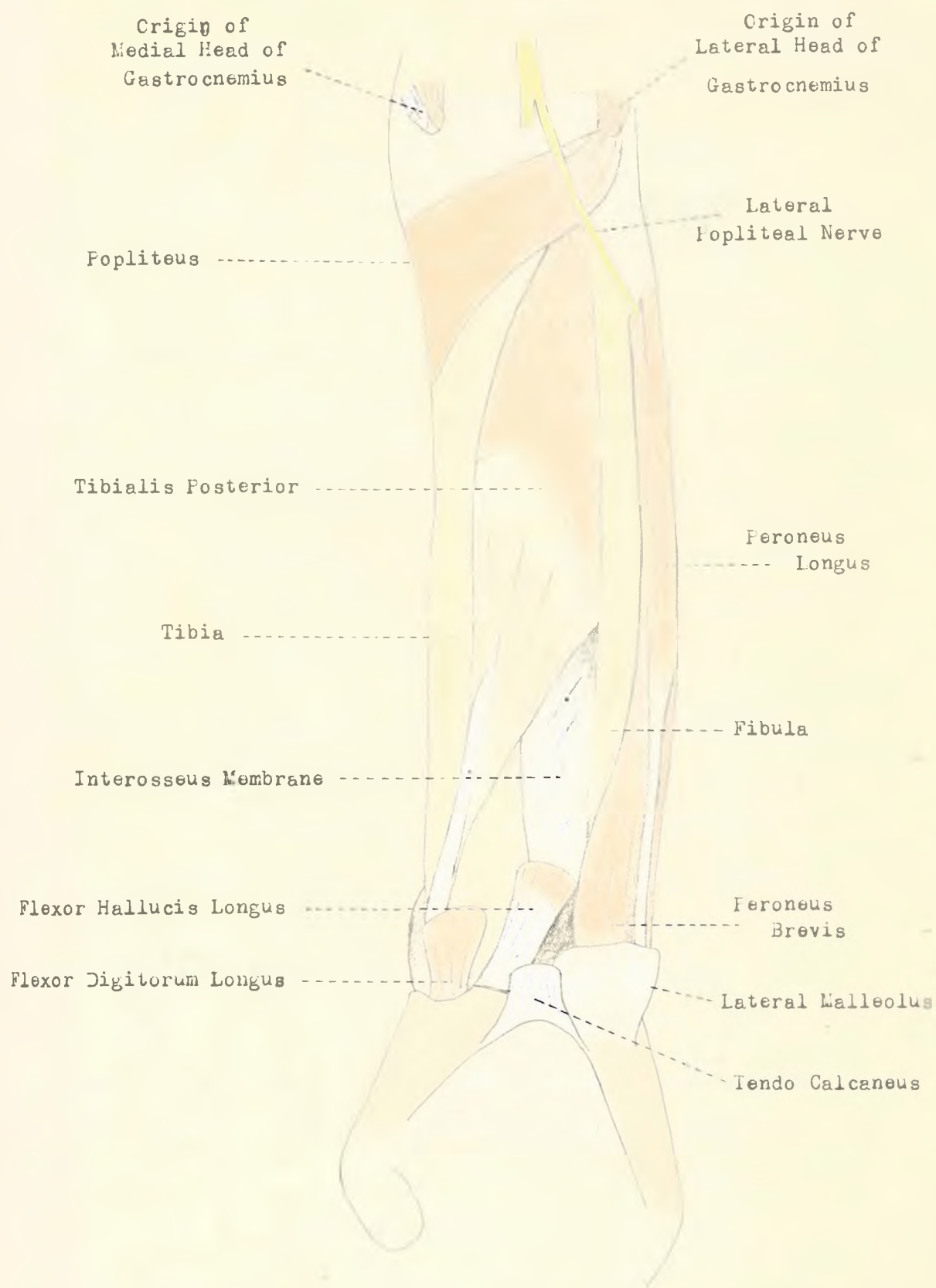
Boyer gives a description of this muscle which corresponds very closely to the muscle described above.

TIBIALIS POSTERIOR: Origin is from the lateral and posterolateral surfaces of the proximal one-third of the shaft of the tibia; from the posterior surface of the superior fibulo-tibial joint; from the medial surface of the proximal half of the shaft of the fibula; and from the whole of the posterior surface of the interosseous membrane in the proximal half of the leg.

(Figures 38, 39).

It gives rise to a long slender tendon which passes round the medial malleolus in its own fibrous compartment, medial to the Flexor Digitorum Longus. (Figure 48). It inserts into the navicular and medial cuneiform bones on their plantar surfaces; into the intermediate and lateral cuneiform bones; into the sheath of the peroneus longus; and into the bases of the second and third metatarsals and partly into the fourth.

Boyer gives the origin as from the proximal two-thirds of the interosseous membrane, the medial border of the fibula and the lateral border of the tibia. Primrose found the origin limited to the upper one-third of the leg.



MUSCLES OF THE SOLE OF THE FOOT.

ABDUCTOR HALLUCIS: The origin was found to be from the medial surface of the posterior tubercle of the calcaneum, and from the medial border of the plantar aponeurosis to a great extent. A little more than the lateral half of the belly of this muscle arises solely from the plantar aponeurosis.

It gives rise to a long flat tendon which inserts into the medial surface of the base of the proximal phalanx of the hallux, fanning out as it does so. (Figures 36, 42, 43).

Sonntag mentions the calcaneal origin but not the attachment to the plantar aponeurosis. Hepburn describes the muscle as receiving fibres from the internal annular ligament and inner side of the proximal part of the first metatarsal bone. Boyer describes the origin as being from the tibial and posterior surfaces of the calcaneum and from the proximal portion of the plantar aponeurosis. Primrose states that this muscle is well developed in the anthropoids and in all apes.

ABDUCTOR DIGITI MINIMI: The muscle arises by fleshy fibres from the lateral surface of the posterior portion of the calcaneum and from the adjoining plantar surface deep to the plantar aponeurosis; from the plantar aponeurosis to some extent; from the lower portion of the Inferior Peroneal retinaculum; and from the fascia separating it from the Flexor Digitorum Brevis.

The muscle is thick and is oval-shaped. It converges anteriorly to give rise to a thin tendon which inserts into the lateral surface of the base of the proximal phalanx of the fifth digit, the tendon spreading fan-wise at its insertion, the upper border becoming fused with the lateral edge of the extensor sheet of the fifth digit. (Figures 33, 42, 43).

Sonntag found the origin from the greater part of the length of the os calcis and from the sheath of the tendon of peroneus

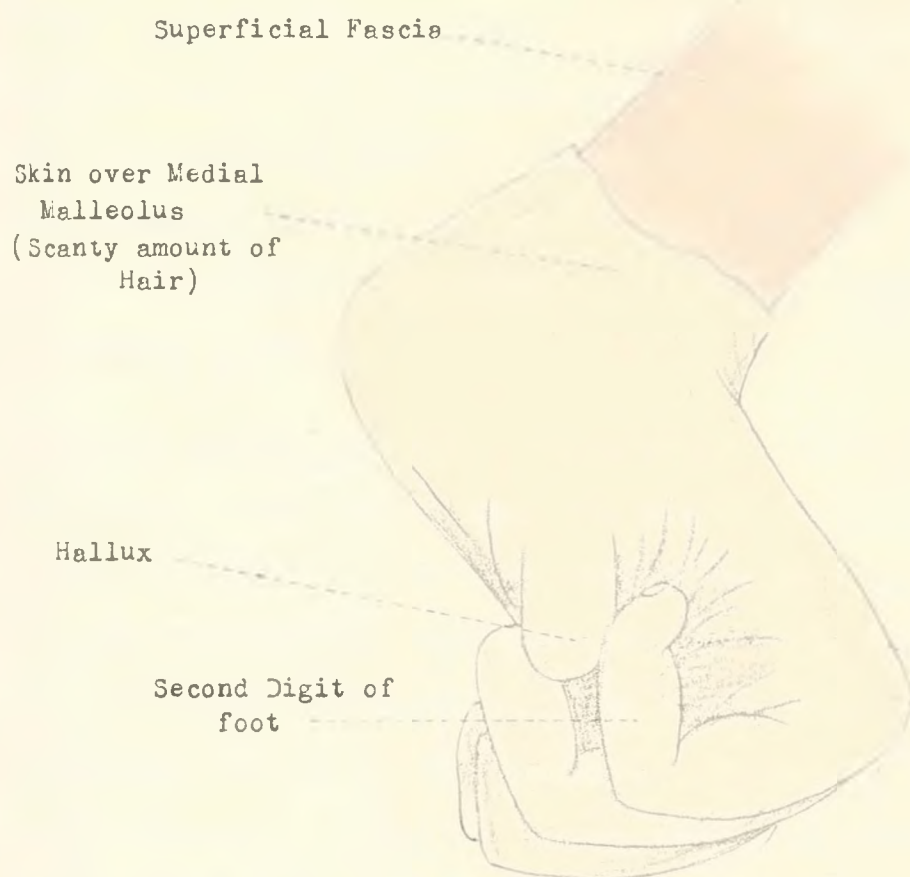


FIGURE 10. Medial aspect of the right foot.
(Lippincott, 1941)

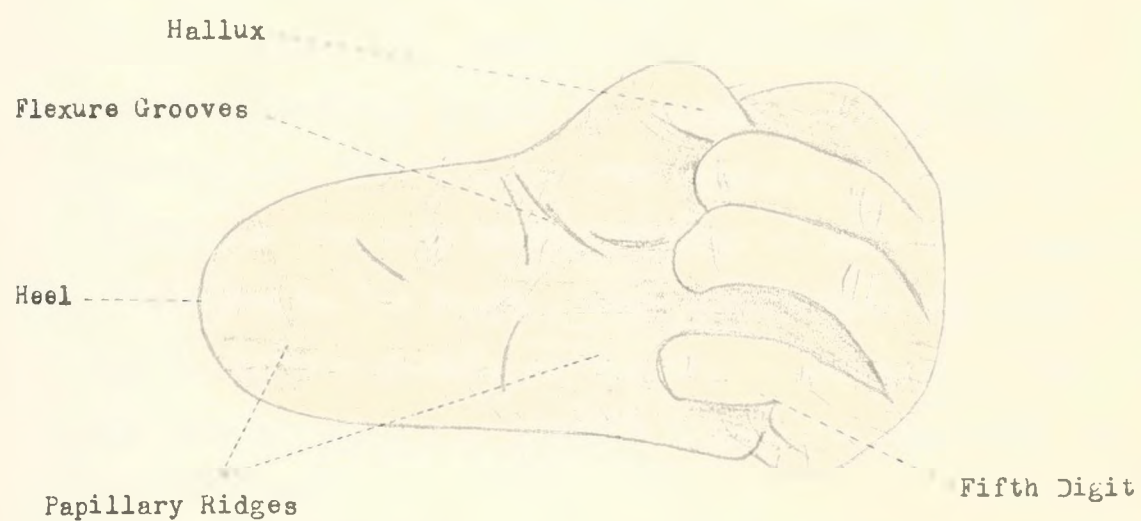


FIGURE 11. Plantar aspect of the right foot.
(Lippincott, 1941)

longus. Boyer finds the origin to be from the plantar and fibular surfaces of the calcaneum, the entire portion of the tibial edge of the muscle joining intimately with the plantar aponeurosis. The inserting tendon was found to split into two, one part blending into the dorsal expansion of the extensor tendons and the other part - much the larger - fastens firmly to the fibular surface of the fifth metatarsal near the metatarso-phalangeal joint.

FLEXOR DIGITORUM BREVIS: This muscle is divided into a large superficial head, which supplies digits two, three and four, and a small deep head which supplies digits four and five.

The superficial head consists of two laminae, not quite separable from one another. The larger deep lamina arises from the medial surface of the posterior portion of the calcaneum, its origin extending along the medial border of the inserting portion of the tendo Achilles for some little distance. The smaller superficial lamina arises from portion of the medial surface of the posterior tubercle of the calcaneum and from the plantar surface of this tubercle. It also gains considerable origin from the overlying plantar aponeurosis.

The deep and superficial laminae fuse and then give rise to three digitations: two small medial ones and a large lateral one. The medial digitations supply the second and third digits. The large lateral one supplies the fourth digit. Their tendons split and let through the deep flexor tendons as with the tendons of Flexor Sublimis in the hand. They insert into the middle of the shaft of the middle phalanx of the digits supplied. The tendon to digit four is joined by a small tendon from the deep head. (Figures 43, 44).

This "deep" tendon to the fourth digit comes off from the bifurcation of the tendon of the flexor digitorum longus. It then



passes forwards and fuses half-way down the sole, with the deep surface of the tendon from the superficial head of the muscle to the fourth digit, forming the greater part of the ensuing common tendon. (Figure 45). The tendon to the fifth digit is very small and slender, arising from a long thin muscle belly which gains origin from the lateral side of the commencement of the slip to digit four, from the flexor digitorum longus tendon. This muscle belly is much thinner and much smaller than a lumbrical muscle of the foot. Its tendon inserts similarly to the other tendons of this muscle, namely, by splitting and allowing the deep flexor tendon to pass through it.

Sonntag records this muscle as arising from the front and inner aspect of the calcaneum, and is partly overlapped by and fused with the abductor hallucis. He mentions that the origin shows a tendency to division into superficial and deep bellies - divisions which would correspond to the laminae of the Superficial head of the muscle described above. He gives the insertion of the muscle as being into the second and third digits. Hepburn mentions three tendons to the second, third and fourth toes, the latter being a mere adjunct to the flexor digitorum longus. Boyer describes this muscle as consisting of a superficial and a deep portion, but these correspond to the superficial and deep laminae of the Superficial head of the muscle described above. The origin of the superficial and deep portions of Boyer agree, to a great extent, with the origin of the superficial and deep laminae above. This author (Boyer) finds the muscle giving rise to four tendons which attach, not the middle as mentioned above, but to the proximal portion of the middle phalanx of the four outer toes. Thus, the deep head as described for the muscle above, is not mentioned by any of these authors.

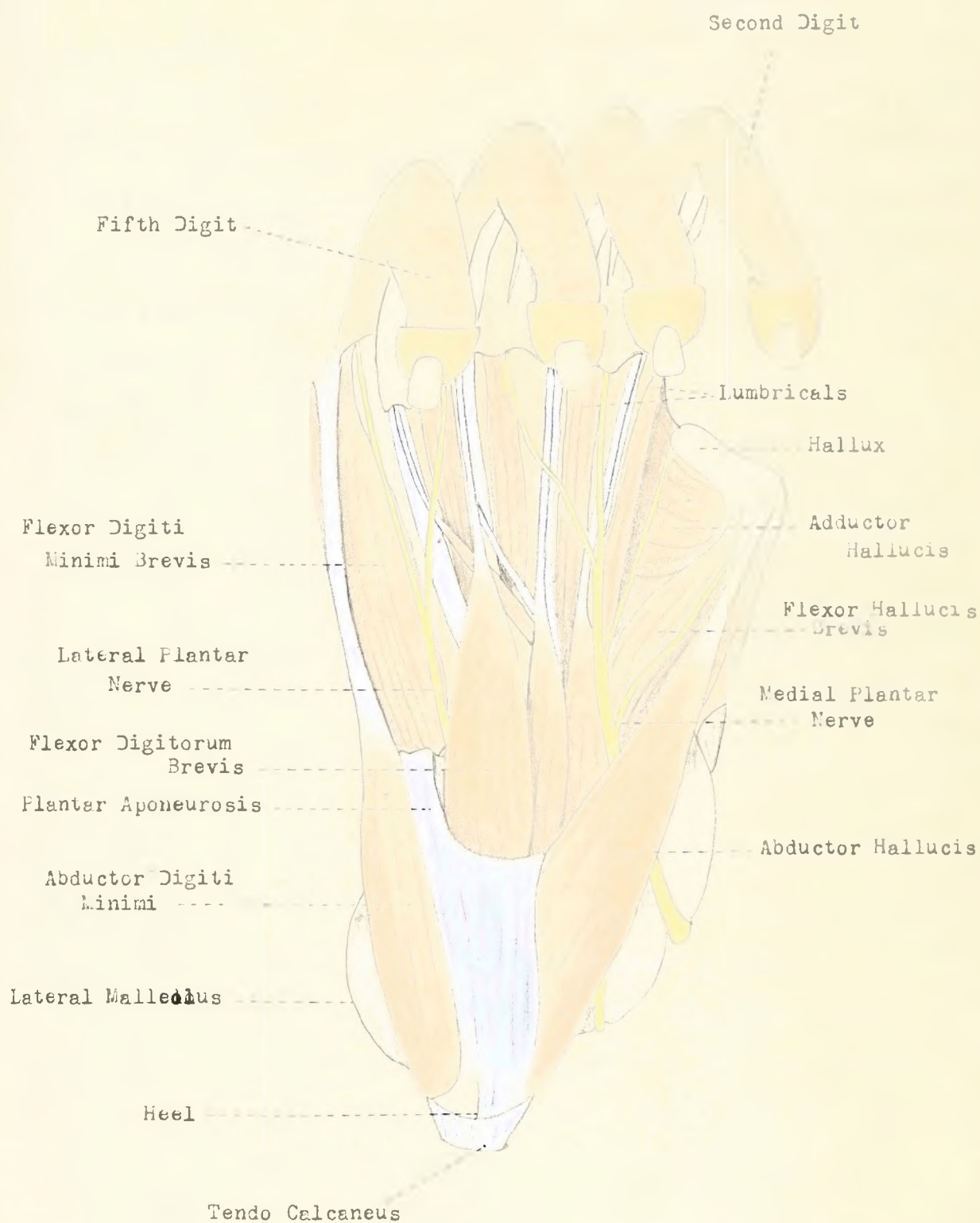


FIGURE 11. DEEPER MUSCLES OF SOLE OF RIGHT FOOT (Superior view)

FLEXOR DIGITORUM ACCESSORIUS: This is found to be rather a small, flat, thin muscle. It takes origin from the postero-lateral portion of the plantar surface of the calcaneum, overlapping slightly on to the adjacent lateral area; and from the anterior slope of the posterior tubercle of the calcaneum. (Figure 45). It lies deep to the origin of the Flexor Digitorum Brevis. The muscle belly gives rise to a slender tendon which fuses with the deep flexor tendon of the Flexor Digitorum Longus to the fifth digit. This, then, represents only the lateral head as compared with the human medial and lateral heads.

Sonntag reports this muscle to be absent in his orang. Boyer and Hepburn, likewise, failed to find the flexor digitorum accessorius in their animals. This muscle is also constantly absent in the gibbon, but it is present in a rudimentary state in the chimpanzee and gorilla.

FLEXOR HALLUCIS BREVIS: The origin was from the medial portion of the sheath of the Peroneus Longus; from the most anterior portion of the sheath of Tibialis posterior; and from the medial cuneiform bone.

It inserts by a short tendon into the plantar surface of the base of the phalanx of the Hallux. This little muscle is wedged in between the Adductor mass and the Opponens Hallucis and is differentiated from these with difficulty. (Figures 44, 45, 46).

Sonntag and Hepburn both describe this muscle as consisting of a large inner and a small outer head. Boyer does not describe two heads, and reports the origin to be from the tendon of the tibialis posterior and the sheath of peroneus longus near the junction of the first cuneiform with the navicular and cuboid. This author finds the muscle united intimately with the opponens hallucis.

FLEXOR DIGITI MINIMI BREVIS: The muscle was found to take origin

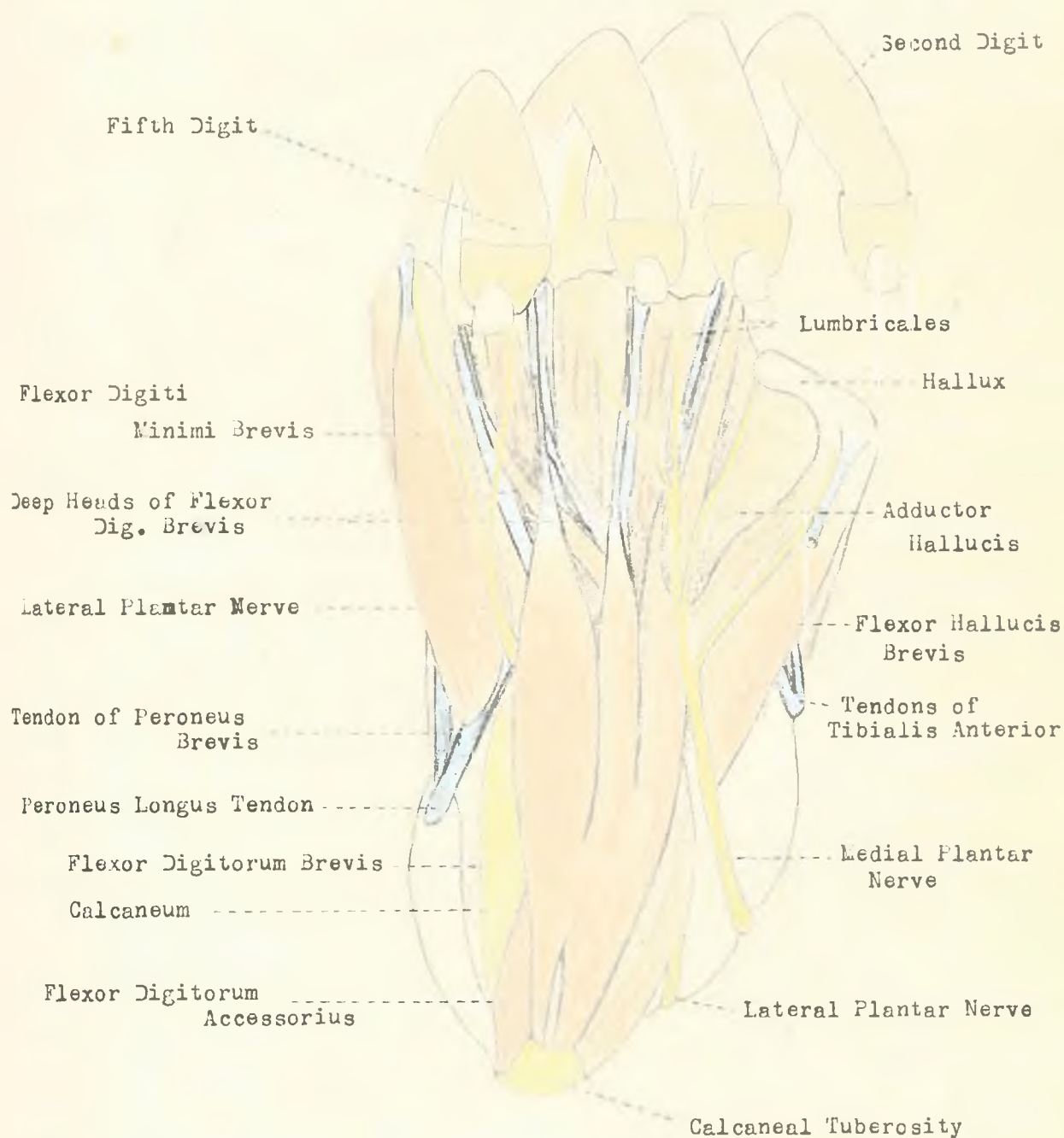


FIGURE 11. MEDIAL VIEW OF RIGHT FOOT. SUPERFICIAL MUSCLES AND NERVES.
 IN THE MEDIAL PLANTAR NERVE. (Ligament of the foot.)

by fleshy fibres from the lateral surface of the base of the fifth metatarsal; from the lateral surface and lateral half of the plantar surface of the shaft of the fifth metatarsal in its whole length (except for its most distal portion); from the extension of the insertion of Peroneus Brevis and from the anterior portion of the sheath of the Peroneus Longus.

It inserts by a short stout tendon into the lateral surface of the base of the proximal phalanx of the fifth digit.

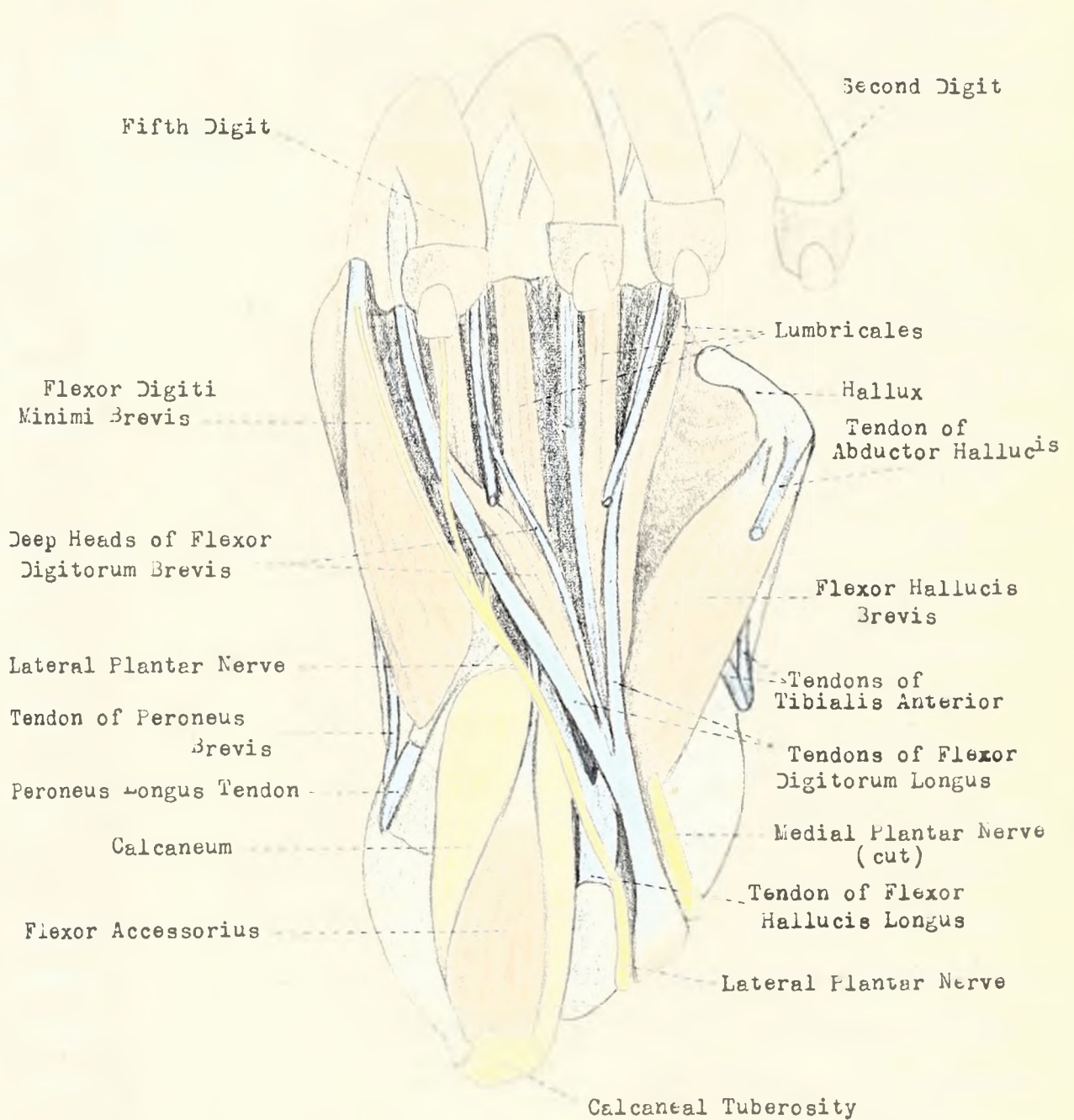
(Figures 43, 44, 45, 46).

A small thin lamina splits off superficially and gives rise to a long thin tendon which passes along the lateral side of the flexor tendons and inserts into the lateral border of the extensor tendon of the fifth digit, half-way down the shaft of the proximal phalanx.

Sonntag reports the origin to be simply from the plantar aspect of the fifth metatarsal bone and sheath of the peroneus longus. He states that it does not receive a slip from the base of the fourth metatarsal bone as described by Hepburn. Boyer describes two heads of origin, one from the under surface of the base of the fifth metatarsal bone, and the other by a narrow fleshy strip to the plantar aponeurosis in the region of the fifth tarso-metatarsal joint.

OPONENS HALLUCIS: The origin of this small muscle was found to be by fibro-muscular fibres from the most anterior portion of the sheath of the Tibialis Posterior; from a small portion of the sheath of the Peroneus Longus; and from the tough transverse ligamentous fibres which lie parallel with and posterior to the long peroneal tendon.

The muscle inserts into the distal three-quarters of the medial surface of the shaft of the first metatarsal. Towards its insertion the muscle divides into two fairly well defined bellies



which diverge to the insertion. (Figure 47).

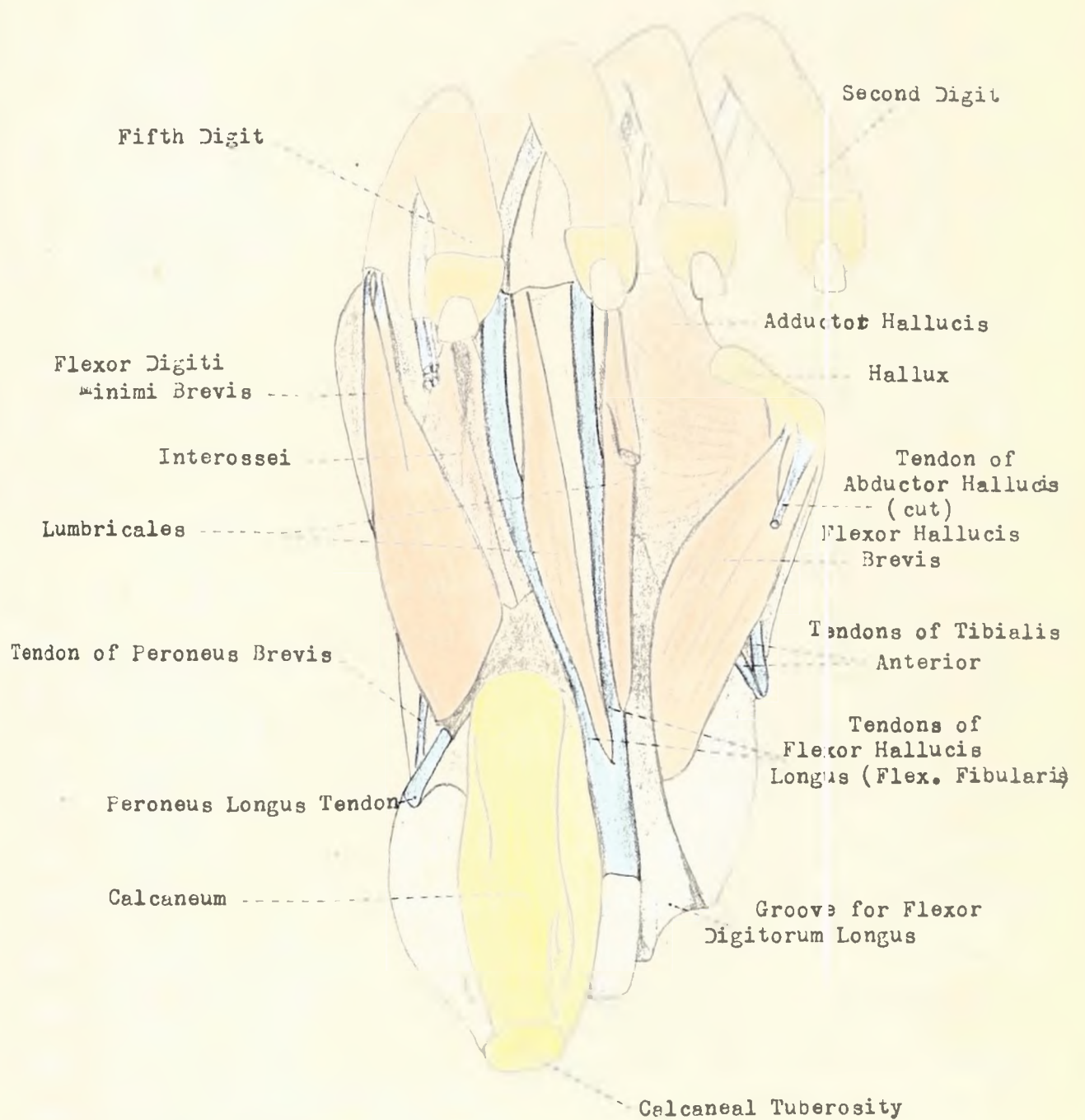
Sountag does not mention this muscle. Boyer reports the muscle as having the same origin as the flexor hallucis brevis and is fused with this muscle throughout its whole length. The insertion is described as being by fleshy fibres into the distal one-third of the first metatarsal bone and the base of the phalanx, just beneath the tendon of the abductor hallucis. Primrose states that in the orang the opponens hallucis is usually weak and is often absent. Hepturn does not mention this muscle, but reports two divisions to the flexor hallucis brevis.

ADDUCTOR HALLUCIS: The muscle was found to arise from the bases of the second and third metatarsals and from the tough ligaments lying between these metatarsals; from the dense membrane covering the interossei; by a dense sheet of fascia from the midline of the shaft of the third metatarsal; by a dense membrane from the distal quarter of the shaft of the second metatarsal bone; and finally, by dense tendinous fibres from the medial halves of the plantar surfaces of the second and third metatarso-phalangeal joints.

The muscle could not be divided into Transverse and Oblique heads, there being simply a large muscle mass. (Figures 43, 46).

A thin sheet of muscle lies in between the Adductor belly and the short flexor belly, arising by fleshy fibres from the most proximal portion of the plantar surface of the shaft of the first metatarsal; from the capsule of the first tarso-metatarsal joint; and from the insertion of the Peroneus longus tendon. It gives rise to a very thin tendon which inserts into the plantar surface of the distal end of the phalanx of the Hallux. This small muscle sheet divides away from the belly of the Flexor Hallucis Brevis more easily than from the Adductor Hallucis mass. (Figure 47).

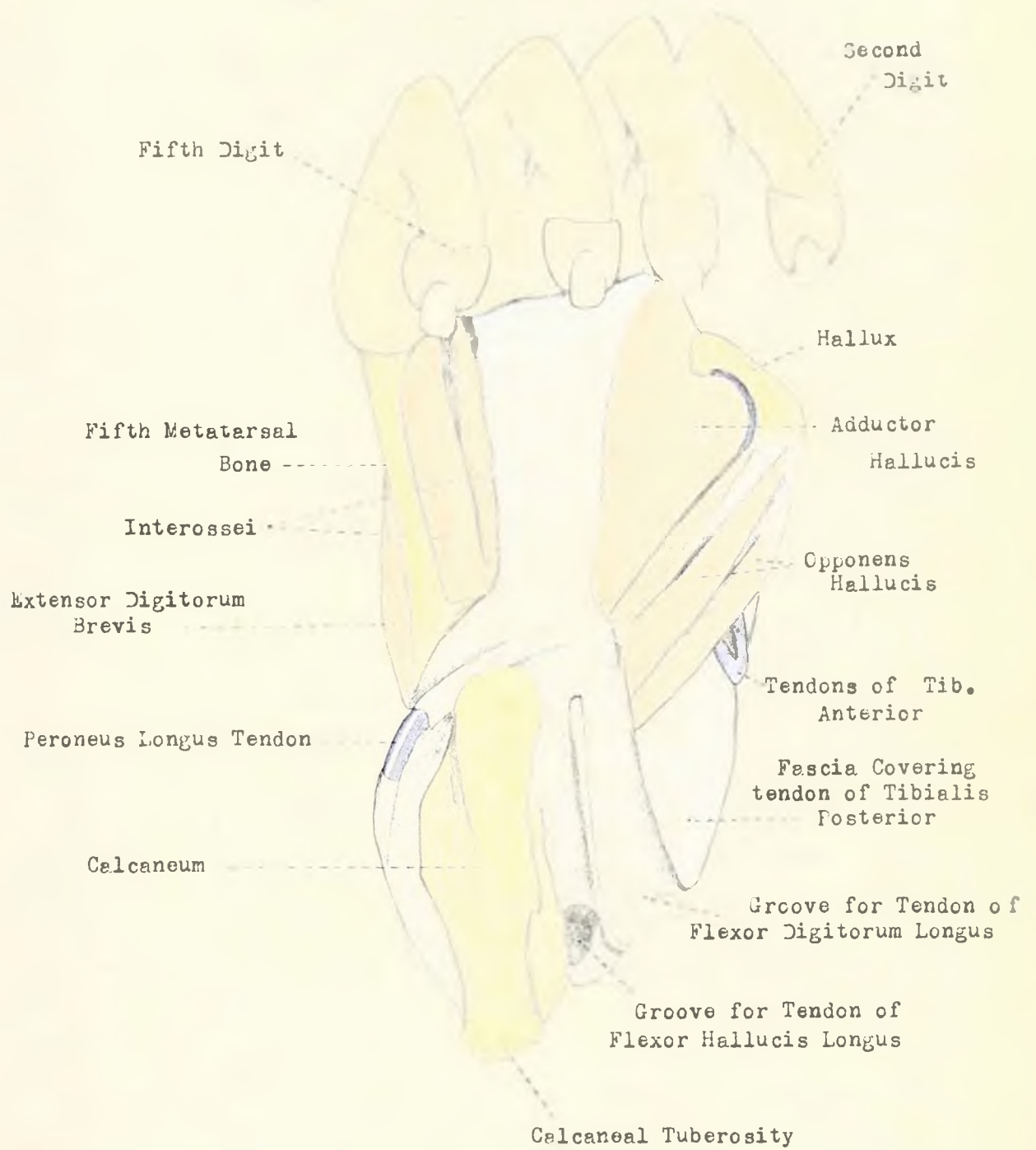
The Adductor Hallucis muscle converges towards the base of the first metatarsal. That part arising from the bases of the second



and third metatarsals, from the deep transverse ligamentous fibres, and from the dense membrane covering the adjacent interossei, insert into the plantar surface of the base of the Hallux. The muscle fibres arising from the third metatarsal and capsules of the second and third metatarso-phalangeal joints insert into the lateral aspect of the base of the phalanx of the Hallux and into the lateral aspect of the capsule of the first metatarso-phalangeal joint. Those fibres arising from the distal quarter of the shaft of the second metatarsal insert into the lateral surface of the distal half of the first metatarsal bone.

Sonntag gives the origin as being from a raphe extending along the plantar aspect of the third metatarsal bone from the tarsus to the metatarso-phalangeal joints; and the posterior limit of the muscular origin is the tendon of the peroneus longus. Boyer reports the muscle as being divided into two heads, the oblique and the transverse. The oblique head is described as arising from the fascia of the plantar interossei in the region of the distal one-third of the second and third metatarsals. A strong slip fastens to the plantar surface of the distal end of the second metatarsal. The transverse head apparently originates from the bases of the second and third metatarsals and the connective tissue along the mid-plantar surface of the proximal one-third of the third metatarsal. This forms a continuous line with the origin of the oblique head. Thus, if the origins of these two heads are considered together they resemble the origin of the muscle described above.

Boyer gives the insert on of the oblique head as being into the distal three-quarters of the dorsal surface of the first metatarsal bone and the tendon of the extensor hallucis brevis in that region. The transverse head inserts upon the lateral and plantar surfaces of the proximal end of the phalanx of the great toe.



Primrose found this muscle divisible into oblique and transverse heads. In addition, he mentions a third muscle which had an insertion into the lower border of the first metatarsal bone. He suggested that this muscle perhaps represents the "second opponens" described by Brooks as derived from the adductor obliques.

DORSAL INTEROSSEI: There are four in number. (Figure 48).

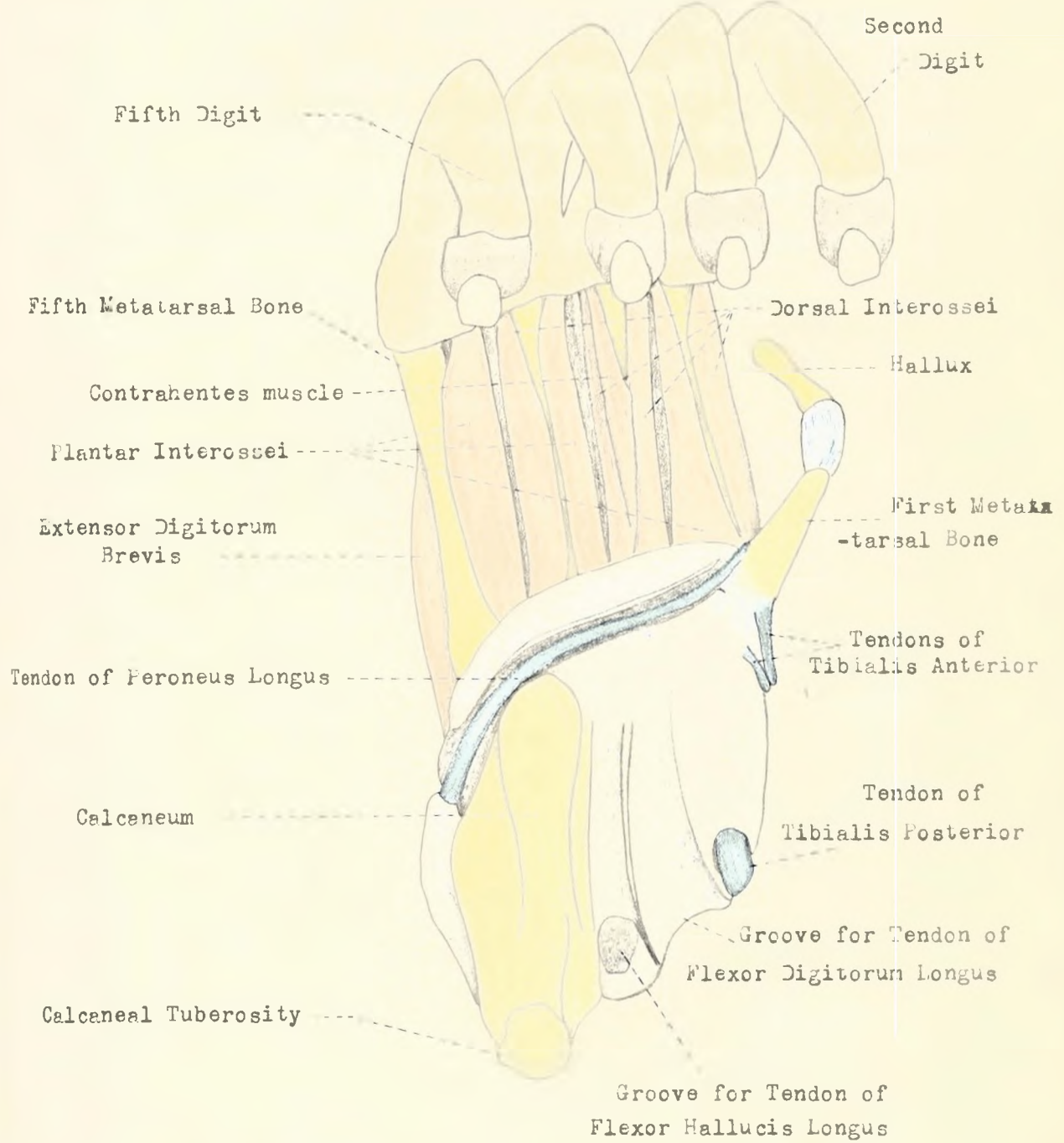
The first dorsal interosseous arises by two heads. The smaller lateral head arises by fleshy fibres from the medial and dorso-medial surface of the capsule of the first carpo-metatarsal joint, and from the medial and dorso-medial surface of the medial cuneiform bone. The larger medial head arises from the lateral surface and lateral half of the dorsal surface of the whole of the shaft of the second metatarsal. The heads fuse and a flat tendon is given off distally near the metatarso-phalangeal joint which inserts into the medial border of the extensor sheet on the dorsum of the second digit.

The other three dorsal interossei arise in bipennate fashion from the adjacent sides of the respective metatarsals. The second inserts into the medial side of the extensor tendon of the third digit. The third inserts into the lateral side of the extensor tendon of the third digit; the fourth into the lateral side of the extensor tendon of the fourth digit.

Sonntag, Hepburn and Boyer find a similar condition in their animals.

PLANTAR INTEROSSEI: There are three in number. (Figure 48).

The first planter interosseous arises by a single fleshy head from the distal three-quarters of the plantar surface of the shaft of the second metatarsal bone. Its tendon passes round the lateral side of the second metatarso-phalangeal joint to insert into the lateral edge of the extensor expansion of the second digit.



The second plantar interosseous arises from the distal three-quarters of the plantar surface of the shaft of the fourth metatarsal bone. It inserts into the medial edge of the extensor expansion on the dorsum of the fourth digit.

The third plantar interosseous arises similar to the previous muscle from the shaft of the fifth metatarsal and inserts similarly into the extensor tendon of the fifth digit.

A similar condition is described by Boyer, but instead of arising from the distal three-quarters of the metatarsals, they arise in this author's orang from the middle three-fifths of the metatarsals concerned.

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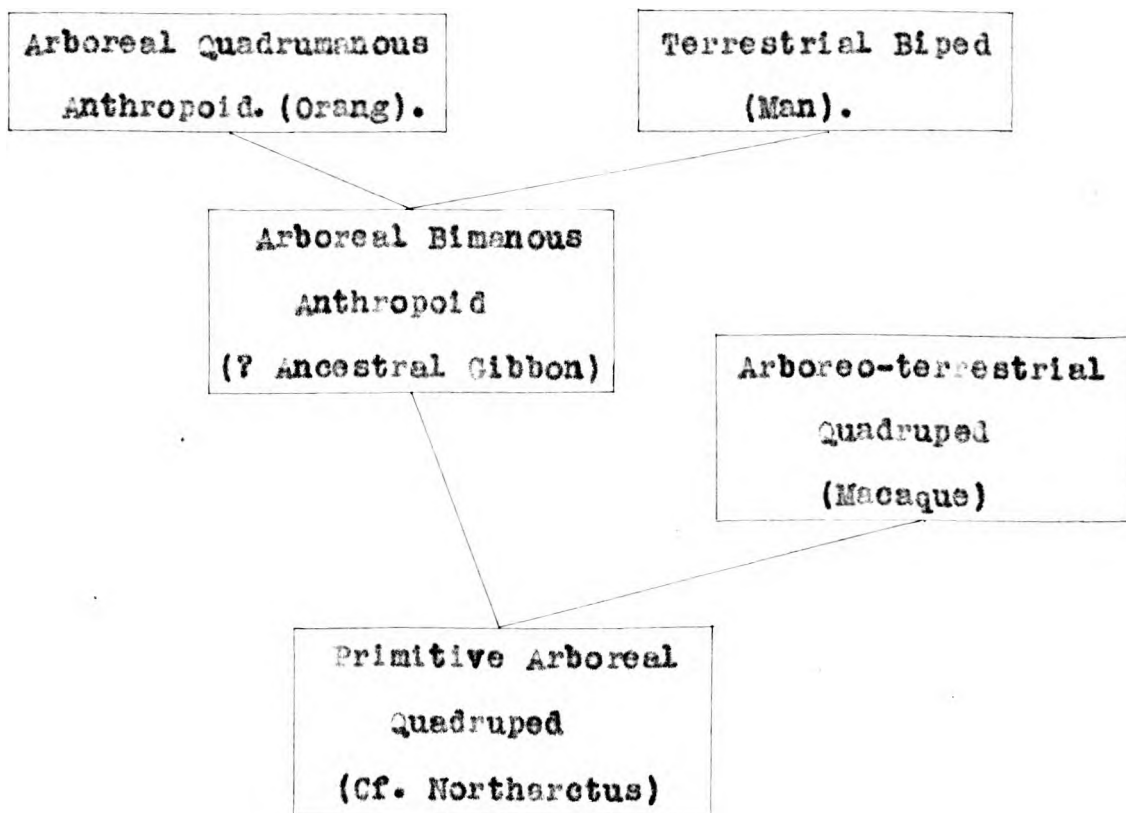
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- P A R T T W O -

- I N T R O D U C T I O N -

The preceding description in comparison with the available literature gives a clear picture of the characteristic features as well as the extent of variation of the limb musculature in the Orang. This picture can be compared with that presented by Man and also by another Primate, whose anatomy has been described in detail, the Phebus Macaque.

In evaluating the significance of these comparisons we must begin by recognizing the fundamental differences in locomotor habits between these three types. The macaque is an arboreal or perhaps more strictly arboreo-terrestrial quadruped, the orang a purely arboreal quadrumanous type, Man a terrestrial biped. It appears, however, that both the latter varieties of habit have been evolved from the first, as indicated in the accompanying diagram. (Cf. Morton, 1926).



All the most primitive living primates either retain the quadrupedal habit or present an obvious specialization of it, and even the most completely known of the Eocene primates (*Northarctus*) possessed this habit. It seems most reasonable therefore to suppose that the Macaque has retained the ancestral habit. Its muscular anatomy is therefore likely to be much nearer to the primitive primate organisation than those of the Orang or Man, and these types almost certainly developed from a condition which is essentially the same as that of the Macaque.

It is probable that Man and the Orang shared a common ancestor which already had undergone a radical change in postural habit compared with the Macaque. This intermediate ancestor was probably an arboreal biped, and may be considered as an ancestral gibbonoid type. Its exact nature however, remains one of the most debatable problems in primate history. Certainly it is highly probable that the existing gibbons are not an unchanged memorial of this ancestral type.

The Rhesus monkey is neither exceptional for unusually long upper limbs or unusually long lower limbs. He may be considered generalized, having the lengths of his upper and lower limbs about equally balanced. The Orang-Utan has, through his specializations, disturbed this balance so that he is found to possess tremendously long and powerful upper limbs, and very short lower limbs, conditions well known and characteristic of this animal. Man, on the other hand, has become specialized in the opposite direction to the Orang, possessing exceptionally long and well-developed lower limbs.

The usual posture adopted by the Rhesus monkey is the pronograde position, both the upper limbs as well as the lower limbs being used for supporting the body and for providing a means of

progression. Both limbs have a subsidiary grasping function. This animal is a very active arboreal denizen, progressing not only by running and climbing along branches but also by frequently jumping from branch to branch.

The Gureng-Utan may be said to adopt a semi-erect posture when progressing over a level surface such as the ground, where he has no supporting branches on which to use his arms. His normal habitat is in the trees, however, and here his upper limbs serve as his main organs of progression. He often uses his lower limbs in conjunction with his upper limbs for climbing, each lower limb being used individually as a separate grasping organ, and climbing by placing one above the other methodically. The animal is slow and sluggish, and only indulges in jumping when this forms his sole remaining chance of escaping from enemies. Both hand and feet are capable of some prehensile action, but the extent of this is diminished, the thumb and great toe both being reduced and almost atrophic. The main function of both hand and foot is a hook-like clasping action of the greatly elongated fingers and toes.

Man is characterized by his upright posture, relying completely on his lower limbs for his means of progression. The human upper limbs have lost their traditional function of supporting the body and aiding in its progression, and are used instead mainly as prehensile organs for manipulation, while the foot has entirely lost its prehensile functions.

The muscle systems of the upper and lower limbs in these three animals may best be compared with one another by considering them in relation to the joints over which they function.

This leads to a comparison of their adaptation to the various movements of these joints, and then to seeing which of the three

animals has relatively the strongest muscular mechanism for each movement of each joint concerned. In this way any features of specialization in certain movements must be illuminated by the various strengths, weaknesses, or other characteristics of the muscle mechanism functioning in each animal.

There are five factors which must be considered in every muscle when comparing it relatively in the different animals concerned. These are:-

- (1): The origin of the muscle and its size.
- (2): The nature of the origin and its relation to the joint over which it is functioning.
- (3): The insertion of the muscle and its size.
- (4): The nature of the insertion and its relation to the joint over which it functions.
- (5): The amount of muscle - and its architecture.

These factors determine the strength and range of movement which any particular muscle can exert over the joint concerned, and therefore, by interpreting the anatomy of the muscles through these five channels a correct estimate of the actual functioning ability of any muscle can be formed.

Considering the various postures more specifically, it is seen that in the characteristic pronograde posture of the Rhesus monkey the scapula is found to be situated rather over the lateral surface of the narrow laterally compressed thorax than over its dorsal surface. In terms of human anatomy the Rhesus macaque's arm is held well flexed and slightly abducted at the shoulder joint, the elbow joint is flexed, while the forearm is pronated. The wrist is extended and the metacarpophalangeal joints of the lateral four fingers are generally hyperextended. In the lower limb the hip joint is flexed to 90° or more; the knee is flexed

and the ankle is slightly dorsi-flexed. There also exists some dorsi-flexion at the mid-tarsal joints, and usually definite extension at the metatarso-phalangeal joints.

In the Orang the scapula is situated more dorsally on a barrel shaped thorax, but not as far dorsally as in Man. For descriptive purposes the typical posture of the limbs may be taken as that which the animal tends to assume when suspended by the arms. The shoulder girdle is usually elevated with the arm well abducted and also almost completely externally rotated. The elbow joint is flexed (sometimes extended), and the forearm is held in pronation. The wrist and fingers are flexed. The thigh is flexed at the hip joint - but not so markedly flexed as the thigh in the *Thesius* macaque. It is also slightly abducted and laterally rotated. The knee is generally held in a flexed position. The ankle has no particular predominance of dorsi- or plantar-flexion, and the outstanding feature of the foot is that it is held markedly inverted.

The human shoulder girdle is depressed and held backwards so that the scapula is placed over the dorsum of an antero-posteriorly compressed thorax. For descriptive anatomical purposes a posture is defined in which the arm is adducted to the side of the body mid-way between flexion and extension, the elbow joint extended and the forearm supinated. The wrist and fingers are held extended in the same axial line as the forearm. The thigh is also extended to a straight line with the trunk and is adducted to the mid-line. The knee is extended and the ankle lies mid-way between plantar and dorsi-flexion, the foot being at a right angle to the leg. It is also in the mid-position between inversion and eversion.

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DISCUSSION ON THE MUSCLES OF THE
UPPER LIMB IN RHESUS MACAQUE, ORANG AND MAN.

The Upper Limb may be conveniently divided, for purposes of this discussion, into the following sections:-

1. Shoulder Girdle,
2. Shoulder Joint,
3. Elbow Joint,
4. The Radio - Ulnar Joints,
5. Wrist Joint,
6. The Hand and its associated small joints.

These will be considered separately in this order.

- 1 -

The Movements of the Shoulder Girdle may be classified into four groups:

1. Upwards,
2. Downwards,
3. Backwards (and Medial-wards),
4. Forwards.

The various muscles which bring about these movements are attached from the axial skeleton to the shoulder girdle, and one muscle may cause the shoulder girdle to pass through more than one of these movements. E.g. The trapezius muscle may be divided into three parts:-

The upper part which draws the shoulder girdle up:
The lower part which draws the shoulder girdle down,
and the intermediate part which pulls the shoulder girdle backwards and medially.

The muscles which pull the shoulder girdle upwards are:-

The upper part of the Trapezius muscle,

The upper part of the Rhomboideus muscle,

The Levator Claviculae and

The Levator Scapulae.

On studying the upper part of the Trapezius muscle in rhesus, Orang and Man, it is found that it is weakest in the rhesus monkey, (for in him there is only a very small occipital origin and a very small clavicular insertion) whereas it is strongest

in the Orang whose occipital origin appears to be extensive. (I found it to arise from the medial one-third of Superior nuchal line; Osgood and Sullivan and Sonntag medial one-half of Superior nuchal line; Hepburn found it arising from the whole Superior nuchal line - right out to the mastoid process). Man takes an intermediate position, as far as this occipital origin is concerned, arising from the medial one-third of the Superior Nuchal line.

In all three the muscle arises from the spines of the cervical vertebrae. In rhesus the muscle attaches directly to these cervical spines; in Orang it attaches directly to the upper and lower cervical spines, and indirectly to the middle cervical spines by means of a commencing ligamentum nuchae; while in Man it arises from the cervical spines almost entirely by means of a well developed ligamentum nuchae.

Of all three, the Orang's muscle is relatively the thickest.

The Upper part of the Rhomboideus muscle is present in rhesus monkey and Orang but absent in Man. The origin is relatively equal in rhesus monkey and Orang, but the latter has a more extensive insertion, being into the vertebral border of the scapula in its whole length, while the rhesus muscle inserts into the vertebral border only from the base of the spine to the inferior angle. (The vertebral border of the rhesus scapula is relatively shorter than that of the human scapula. Orang's vertebral border is intermediate between the two). The rhomboideus present in Man does lift the scapula up a little, but not as much or as powerfully as the fully developed muscle in the Macaque and Orang.

In the Orang the Levator Clavicularae is present; in rhesus monkey this is represented by the atlanto-scapularis anterior or omo-trachelian muscle, inserted into the acromion process. This

does not really imply a great difference in the course of the muscle, for in the Macaque the scapula lies on the side of the compressed thorax, and the gleno-humeral joint is more ventrally situated than in the Orang. In both animals the action of the muscle is probably very much the same. It is present only very occasionally in Man.

In the rhesus macaque the Levator Scapulae muscle has not yet divided from the Serratus Anterior Sheet, but that portion of muscle representing the Levator Scapulae has probably a relative action as powerful as the independent muscle found in Orang and Man. The Levator Scapulae muscle has the same origin in Orang as in Man, but in the former the insertion is limited more to the superior angle of the scapula. Relatively the Orang's muscle is heavier than the human muscle.

So, all in all, the animal which has the strongest and best developed muscular system with which to draw up the shoulder girdle is the Orang. He is stronger in this respect than rhesus and Man in his trapezius and rhomboid muscles, and is about equal to the two in his levator scapulae. This levator claviculae muscle is as powerful as that found in rhesus.

The rhesus musculature which draws the shoulder girdle upwards must be approximately equal to that of Man.

The muscle system which pulls the shoulder girdle downwards consists of the latissimus dorsi, the lower part of the trapezius, the lower part of the pectoralis major and pectoralis minor.

The latissimus dorsi muscle, as far as this particular action is concerned, is weakest in rhesus, for in this animal the origin does not even extend distally as far as the iliac-crest, but stops half-way down the lumbar region. In the action The Orang and human muscle are relatively equal in strength of pulling

the shoulder girdle downwards. The lower part of the trapezuis is again weakest in the rhesus monkey, because in this animal its distal attachment extends only as far as the spine of the 10th thoracic vertebra, while in man and orang it continues down to T.12 (and in Orang, sometimes to L.1).

However, in so far as the lower part of Pectoralis Major is concerned, the rhesus monkey has the strongest action in drawing the shoulder girdle downwards, since it has the true pars abdominalis which orang and man lack. The latter two have better developed lower parts of the costo-sternalis portion of the muscle, but these do not extend so far down on to the abdominal wall as does the pars abdominalis of rhesus. The Pectoralis Minor attaches to the sternum near the midline in rhesus, while in Orang and Man the origin has migrated laterally. Naturally, it follows that this muscle in rhesus cannot have the same force in drawing downwards the shoulder girdle that have the orang and human muscles.

Taken altogether, ther fore, the rhesus has the weakest musculature with which to draw the shoulder girdle downwards, for even though its pectoralis major is probably strongest in this specific action, its latissimus dorsi, lower part of trapezuis and pectoralis minor muscles are all relatively weaker than those of Orang and Man. The orang musculature which draws the shoulder girdle downwards is about equal to that of the human. If anything, the Orang has the slightly stronger musculature of the two for this purpose, since his latissimus dorsi muscle has migrated down the vertebral column and outwards along the iliac crest a little more than has Man's muscle which must consequently result in a purer and stronger downwards pull on the shoulder girdle. The same holds for the pectoralis major muscle in its lower part. In man the pectoralis abdominalis is well fused with the costo-sternalis portion,

while that part of the Orang muscle is quite free and arises more laterally, so that it must have a greater chance of a pure and simple downwards pull on the shoulder girdle. The arrangement of Man's muscle results in a greater division of force since it draws the shoulder girdle not only downwards but also medially.

The shoulder girdle is pulled backwards by the trapezius (especially the intermediate part), the latissimus dorsi, and the rhomboideus muscles.

The trapezius muscle in its intermediate part, exerts relatively the same backwards pull in all three. Even though in the rhesus monkey this muscle extends down only to T.10 while in Orang and Man it does down to T.12, there is not much difference made by this to the backwards or medial pull of the muscle.

In pulling the shoulder girdle backwards the latissimus dorsi is weakest in the Orang, for in this animal the origin extends cranially only as far as T.10, while in the macaque and Man it comes up to T.6. In orang this backward pulling force is sacrificed for a more efficient downward pulling force on the shoulder girdle. The human muscle has a much greater attachment distally than has that of rhesus, and although this causes mainly a downwards pull on the shoulder girdle, it also functions to a considerable extent in drawing it backwards.

Only the lower portion of the rhomboideus muscle acts in drawing the shoulder girdle backwards. In Man and Orang this action is approximately equal, since the muscle origin in both extends down only as far as T.5. In rhesus macaque the muscle origin extends down to T.7. and this greatly increases the value of the muscle as a force for drawing the scapula towards the midline, - and thus drawing the shoulder girdle backwards.

As a whole, therefore, the Orang has relatively the weakest muscular system to draw the shoulder girdle backwards, while the

musculature in Macaque and Man is practically the same in strength.

Lastly, the muscles which will draw the shoulder girdle forwards are the Serratus anterior, the Pectoralis Major and the Pectoralis Minor. The Serratus anterior muscle is relatively weakest in Man, since in him it arises from only the upper 8 or 9 ribs, while in rhesus and orang this muscle is about equal, arising from the upper 10 or 11 ribs.

The Pectoralis Major is strongest in drawing the shoulder girdle forward in Man, for he has the best developed sterno-costal portion of the muscle of the three animals. It is of about equal force in macaque and orang. The important part of the muscle for this function is the sterno-costal part, as its main action here is to pull the shoulder girdle in a purely forwards direction - unlike the lower portions of the muscle which draw the shoulder downwards as well as forwards.

The Pectoralis Minor is strongest in pulling the shoulder girdle forwards in rhesus monkey, as in this animal the muscle arises adjacent to the midline, and consequently has a greater forwards pull than a downwards pull - a state of affairs reversed in Orang and Man who have their pectoralis minor muscles arising far out laterally from the midline.

So, taken in all, the rhesus macaque is the animal which has definitely the greatest force, relatively of the three, with which to pull forwards his shoulder girdle.

Reviewing and summarizing the above it is found that the strongest in each action on the shoulder girdle is as follows:-

<u>Upwards:</u>	: Orang.
<u>Downwards:</u>	: Orang, closely seconded by Man.
<u>Backwards:</u>	: Rhesus macaque, closely seconded by Man.
<u>Forwards:</u>	: Rhesus macaque.

Thus the Orang has the greatest and strongest relative force of the three with which to draw his shoulder girdle upwards and downwards - actions greatly used by this animal when climbing in his arboreal haunts.

The sus monkey is outstanding in his ability to pull the shoulder girdle backwards and forwards - actions greatly used in the pronograde posture, where the upper limb and shoulder girdle must support the trunk.

Finally, Man's relatively strongest forces over his shoulder girdle are to draw it downwards and backwards - movements which produce the "square" shoulders, with their horizontal clavicles, characteristic of the upright posture of Man.

- 2 -

The next focus of movement in the upper limb which is of interest is the shoulder joint. Here there are six possible movements:

Adduction,
Abduction,
Flexion,
Extension,
Medial Rotation and
Lateral Rotation.

The various muscles acting on the shoulder joint may control more than one of these movements. There are a great number of muscles which may cause Adduction of the humerus. These are:-

Teres Minor,
Teres Major,
Latissimus Dorsi,
Dorso-epitrochlearis,
Pectoralis Major,
Coraco-brachialis,
Short head of Biceps and
Long head of Triceps.

The Teres Minor muscle acts as a lateral rotator as well as an adductor of the humerus. Taking it purely in the light of an adductor muscle we see that it is strongest, relatively speaking,

in Man as compared with the Rhesus monkey and Orang. The characteristic that makes it so in Man is that it inserts not only into the lowermost facet of the greater tuberosity of the humerus - like the muscle in Rhesus and Orang, but it also extends downwards from this on to the shaft of the humerus for some distance, ($\pm 1''$), this extension giving the muscle greater leverage over the shoulder joint for adducting the humerus. Even though the Rhesus muscle may have a slightly greater origin from the axillary border of the scapula than Man, this cannot make up for the adducting power gained by this distal extension of the human insertion. The Rhesus muscle may have a relatively greater origin than that of the Orang, but though it is a more powerful adductor than the Orang muscle, it cannot be by very much, since, due to the very proximal insertion found in both these animals, the adducting action as such must be weak, the main action being rather one of lateral rotation.

The Teres Major muscle acts as a medial rotator as well as an adductor of the arm, the latter action being quite as powerful and conspicuous as the former, owing to the insertion being some way down on the shaft of the humerus, enabling the muscle, therefore, to have some leverage on the shoulder joint. The insertion is very much the same in Man, Orang and Rhesus macaque, so that the relative power of the muscle now must depend on the bulk of the muscle and the area of origin, the greatest in these necessarily being the strongest. Actually the Orang and human muscle are about equal in origin, the Orang muscle possibly being a little stronger due to a slightly more extensive origin and a relatively more bulky muscle. However, the difference is not great. For this muscle both Orang and Man are much more powerful than macaque, since in the latter the muscle arises from the lateral surface of the expansion of the gleno-vertebral angle of the

scapula, which corresponds perhaps to a little more than the lower quarter of the axillary border of the scapula. In Man and Orang it arises at least from the lower one-third of this border.

The Latissimus Dorsi is a powerful adductor muscle of the humerus. The proximal fibres have a greater adductor force than the distal fibres of the muscle, as the latter cause extension of the arm rather than adduction. Of the three primates concerned, Man has the best muscle for adduction. It is better than the Orang's muscle because it arises more proximally than does the orang's muscle, and it has in addition origins from the scapula and lower four ribs, thus giving it a more powerful action generally, but especially in its proximal part: i.e., that part of the muscle in which the adducting action is relatively greatest. The human muscle is superior to that of the rhesus monkey as an adductor because of its far more extensive origin. Even though the origin of rhesus muscle extends up as high as the origin of the human muscle, it does not extend as far downwards, stopping half-way down the lumbar region, while the human muscle origin continues right down on to the iliac crest. It has, in addition, the costal and scapular origins which rhesus muscle has not. Though the distal fibres of the muscle have not the same adducting power as have the proximal fibres, nevertheless, they do cause considerable adduction at the arm; so, as a result the human muscle is a much stronger adductor than the rhesus muscle.

The Dorso-epitrochlearis muscle is an adductor of the arm. It appears normally in both rhesus monkey and orang, but appears only occasionally in Man. The muscle is relatively much the same in macaque and Orang, so that its action must be about equal in these two animals.

The Pectoralis Major is a powerful adductor and a medial rotator of the arm, the upper part of the muscle having the greatest

adducting force - the lower part tending to pull the humerus downwards besides adducting it. The upper part of the muscle is best developed relatively in Man, since he has a large clavicular head which Orang and Rhesus macaque lack, and in addition the upper part of the Costo-Sternal portion of his muscle has relatively the strongest origin. The lower portion of the Pectoralis Major is least developed in Orang, since in this animal the muscle does not spread so far distally on the trunk as it does in Man and Rhesus monkey. So, on the whole, the human Pectoralis Major has the greatest relative force for adducting the humerus - the Rhesus muscle being weaker, because of its weak proximal portion the Orang's muscle being weaker because of both its weak proximal and distal portions.

The Coraco-Brachialis muscle is an adductor and a flexor of the arm. As an adductor muscle it is strongest in the Rhesus monkey, because in this animal a fuller complement of the muscle is present, i.e., both the profundus and Medius are found. The Profundus (i.e. Superior) part is absent in Orang and Man, but the Medius of the Rhesus macaque corresponds fairly closely with the muscle belly in Orang and Man. Thus, if only the medius were present alone in all three animals, the relative adducting forces would be about equal; but since the Rhesus monkey has the Profundus portion as well - no matter if it has not a great adducting force - it will cause the Rhesus to be the strongest of these three primates.

The Short Head of Biceps has a weak adducting action on the arm, but this must be relatively equal in force in Macaque, Orang and Man.

The Long Head of Triceps has a considerable adducting force on the arm. In Rhesus and Orang this head has a very much more extensive origin than in Man, and this not only enables it to be

stronger, because of the greater number of muscular fibres, but also because of the greater leverage on the arm. (Man's bony origin is simply from the infraglenoid tubercle, but Rhesus monkey and Orang have their bony origin from both the infraglenoid tubercle and the lateral half of the axillary border of the Scapula).

Reviewing the adductors of the arm we see that, relatively speaking, the Teres Minor, the Latissimus Dorsi and the Pectoralis Major are strongest in Man, while the Teres Major is strongest in Man and Orang. The Coraco-brachialis is strongest as an adductor in Rhesus macaque, while the Dorso-epitrochlearis and Long Head of Triceps are greatest in the Macaque and Orang. The Short Head of Biceps are equal in all three.

Man has a stronger muscular mechanism for adduction, relatively, than has the Rhesus monkey, for though the latter is stronger with the Coraco-Brachialis, the Dorso-epitrochlearis and Long Head of Triceps, Man is stronger with the Teres Minor, Teres Major, Latissimus Dorsi, and Pectoralis Major muscles. The latter group of muscles, and especially the latter two muscles, rather tip the balance in favour of Man being the stronger of the two for adduction.

The Rhesus monkey has its Pectoralis Major and Coraco-Brachialis muscles relatively stronger at adduction than these muscles in the Orang. The Teres Major, on the other hand, is strongest, for adduction in the Orang, but this is more than counter-balanced by the above two muscles, so that the Rhesus macaque is stronger at adduction than Orang.

So, taken as a whole, Man is the strongest at adduction, followed by Rhesus monkey and then the Orang. Yet, in view of the human adductor muscles being relatively the strongest of all three animals, it appears anomalous that the dorso-epitrochlearis-

almost entirely an adductor muscle - should be absent in Man alone.

The muscles producing Abduction are the

Supraspinatus (which initiates this movement)
the Deltoid; and to a slight extent the
Long Head of Biceps.

The Supraspinatus muscle is comparatively most powerful in rhesus monkey because in this animal the muscle is composed of three parts. The main part of the rhesus muscle which fills the supraspinatus fossa is very similar to the muscle in Man and that in Orang. However, in addition, there are two slips, the "pars superior" arising from the cranial border of the scapula from the attachment of the omohyoid to the coracoid process, and the "pars inferior" which arises along the cranial border of the scapular spine, and these give the rhesus muscle some (though possibly slight) superiority in force over the human muscle and Orang muscle.

The Deltoid has the greatest origin in the rhesus monkey, since it arises from the whole length of the clavicle, acromion process and by a tough aponeurosis from the caudal border of the scapular spine, and from the gleno-vertebral angle of the scapula. The Orang origin is less extensive, and that of Man least extensive of all, being limited to the lateral half and lateral one-third of the clavicle respectively, plus similar reduction in the origin from the scapular spine and infraspinatus fascia.

The Long Head of Biceps exerts probably a comparatively similar force in all three.

As a whole, therefore, since Rhesus macaque is strongest both in Supraspinatus muscle and Deltoid muscle, it must have the greatest relative Abducting force of all three primates. Orang comes next, being stronger than Man who, thus, is the weakest of the three.

The muscles causing Flexion of the arm are:-

The anterior fibres of the Deltoid,
The upper fibres of the Pectoralis Major
(especially the clavicular head),
The Coraco-brachialis,
The short head of Biceps (weakly), and if the
arm is abducted to 90° ,
The Subscapularis.

The anterior fibres of the Deltoid are relatively strongest in their action in the *Macacus rhesus*, since in this animal they have the greatest origin from the clavicle. In the macaque the anterior part of the Deltoid arises from the whole length of the clavicle; in Orang ^t arises from the lateral half of the clavicle, in Man only from the lateral one-third. Thus the flexion force must be greatest in *rhesus* monkey, then in Orang and finally weakest in Man.

However, Man makes up for this weakness by using the extensive clavicular head of the Pectoralis Major, which occupies the medial half or two-thirds of the clavicle. This clavicular head plus the anterior fibres of the Deltoid, together occupying the whole length of the clavicle, must give a resultant flexion force about equal to the anterior fibres of the Deltoid in *rhesus*. Neither *rhesus* macaque nor Orang possesses a clavicular head of origin for their Pectoralis Major muscles. But any flexion force exerted by the upper fibres of the Pectoralis Major in *rhesus* and Orang must also exist in Man, since the upper fibres of his costo-sternal part of the muscle will execute this function. The short head of Biceps can only exert a weak flexion force on the shoulder joint, and relatively speaking, this force should be about equal in all three primates under consideration.

Up to now, therefore, *rhesus* macaque and Man are comparatively equal in the sum of their flexion forces, the Orang being weaker than either, due to its having the medial half of its clavicle unoccupied by either Deltoid or Pectoralis Major.

The final flexor muscle, the Coraco-Brachialis, decides in

favour of the Rhesus being relatively the strongest at flexion of the arm, because this animal possesses both the Profundus as well as the Medius portions of this system of muscles, whereas Man (and Orang) lack the Profundus portion having only the Medius.

Though this profundus part of Coraco-Brachialis cannot have a very powerful flexor action, nevertheless it makes the flexor muscular system relatively strongest in the Rhesus monkey, then next in Man and finally weakest in Orang.

If flexion is performed when the arm is abducted to 90° then the subscapularis muscle will come into action as a flexor. When this occurs Man's flexor force will more nearly equal Rhesus' flexor force, because in the human the insertion of this muscle extends more distally (on to the shaft of the humerus) than it does in Rhesus and this should just about make up for the extra flexor force given in the Rhesus by the Profundus portion of Coraco-Brachialis.

The action of Extension of the Shoulder Joint is brought about by the posterior fibres of the Deltoid muscle and by the Latissimus Dorsi muscle. When the humerus is fully flexed the costo-abdominal portion of Pectoralis Major helps in extension. The posterior fibres of the Deltoid have the most extensive origin in Rhesus monkey, since in this animal they arise from the posterior part of the lateral border of the acromion, and by a tough aponeurosis from the caudal border of the scapular spine and from the gleno-vertebral (i.e. inferior) angle of the scapula. In Orang the origin is less extensive: arising from the posterior part of the lateral border of the acromion, from the lateral half of the inferior border of the scapular spine and from the upper part of the infraspinatus fascia. In Man the origin is from the posterior portion of the lateral border of the acromion and from nearly the whole length of the inferior margin

of the scapula spine, and only slightly from the infraspinatus fascia.

The posterior margin of the Deltoid muscle in Rhesus monkey is thus much lower relatively than that of Orang and Man, and similarly that of Orang is lower than that of the human muscle. These fibres must exert thus a greater force in extension and lateral rotation in the macaque than in Orang and Man, and greater in Orang than in Man.

The Latissimus Dorsi has the greatest origin in Man since it attaches higher up the spine than in Orang and more distally than in Rhesus monkey and also gains attachment to the scapula and lower four ribs - additional origins which are lacking both in Orang and Rhesus macaque. The origin is greater and more suitably placed for extension of the arm in Orang than in the macaque. Thus, Man has the greatest extensor force in comparison, as far as the Latissimus Dorsi is concerned, and this superiority over Rhesus monkey here more than counteracts the superiority of the posterior fibres of Rhesus' Deltoid. Man's greater force in his Latissimus Dorsi over the Orang perhaps equals or more than equals the superiority of the posterior fibres of the Orang's Deltoid Muscle.

So, thus far, the human has the greatest relative extensor force on the arm, with Orang a close second, and Rhesus last.

If the arm is fully flexed the costo-abdominal portion of Pectoralis Major helps in extension. This part of the muscle is best developed in Man.

The fifth movement at the Shoulder is that of Medial Rotation. This is brought about by the anterior fibres of Deltoid, the Teres Major, Subscapularis, Latissimus Dorsi and Pectoralis Major.

The anterior fibres of the Deltoid, as has been stated already, have the greatest relative origin in Rhesus monkey, then in Orang, and lastly in Man, since the origins are from the whole length of

the clavicle, the lateral half of the clavicle, and the lateral one-third of the clavicle respectively. This is again made up in Man by the clavicular head of the Pectoralis Major - a head lacking in Orang and Rhesus monkey. On this fact alone the conclusion may be drawn that the human and Rhesus macaque are approximately equal in their medial rotating forces, the Orang being relatively weaker. The remainder of the Pectoralis Major - especially the costo-abdominal portion, is best developed in Man. For medial rotation the Pectoralis Major of the Orang is better attached and better situated than the Rhesus muscle, and so probably has greater force than the Rhesus monkey in this movement. (The Orang muscle has origin not only from the manubrium and body of the sternum, but also from the adjacent costal cartilages. Rhesus muscle attaches only to manubrium and sternum.

Again, the "abdominal" portion of Orang is placed more proximally than that part in Rhesus monkey, and so it will have a more direct medial pull than the Rhesus muscle which will spend a great deal of its energy not only pulling medially but also downwards).

The Latissimus Dorsi has the most extensive origin in Man, less in Orang, and finally least extensive in Rhesus macaque, as has been said before. This gives the human muscle greatest force in medial rotation with the Orang muscle coming second and the Rhesus muscle last.

The Teres Major muscle has the weakest origin in Rhesus monkey, the Orang and Man being about equal - if anything the Orang being a little more extensive. (In this latter animal the origin occupies the lower half of the axillary border of the Scapula, whereas in Man it usually arises from the distal one-third of this border. In the macaque it springs from about the distal one-quarter.)

The insertions are the same in all three. The medial

rotating force is thus most powerful in Orang and Man, and weakest in Rhesus monkey.

The Subscapularis has very similar origin in all three animals, but although the insertion is fundamentally the same in all three, the human muscle has a distal extension on to the surgical neck of the humerus. This must give the human muscle a greater medial rotating force than the corresponding muscle in the other two animals. Besides this, the Subscapularis muscle is able to function as a medial rotator far more efficiently when the animal is in the upright posture than when it adopts the pronograde position. This is added reason why this muscle is probably a most efficient medial rotator in Man.

Reviewing these muscles, we see that though the Deltoid in Rhesus is more powerful as a medial rotating force than the human Deltoid, Man has really greater medial rotating force than the Rhesus monkey due to his Pectoralis Major, Latissimus Dorsi, Teres Major and Subscapularis muscles. Similarly the Orang is stronger than Rhesus macaque at medial rotation due to the Pectoralis Major, Latissimus Dorsi and Teres Major muscles, and this superiority is greater than that of the superiority gained by the Rhesus' Deltoid over the Orang's Deltoid. The Orang's anterior fibres of Deltoid and possibly the Teres Major muscle exert slightly greater medial rotating force than the human counterparts, but Man has really a superior medial rotator mechanism due to his Pectoralis Major, Latissimus Dorsi and Subscapularis muscles, which are stronger at medial rotation relatively than the corresponding muscles in the Orang.

Thus, Man has the strongest medial rotator mechanism, with Orang a fairly close second, the Rhesus monkey definitely having the weakest medial rotator mechanism of the three.

The last movement of the Shoulder Joint is that of

Lateral Rotation. The posterior fibres of Deltoid, the Infraspinatus and the Teres Minor muscles bring this about. As has been previously mentioned, the posterior fibres are greatest and extend most distally in their origin in Rhesus, then in Orang, and finally in Man.

The Infraspinatus muscle is very similar in all three, it probably being a little more bulky in Rhesus monkey and Orang than in Man.

The Teres Minor muscle enjoys the most extensive origin in the macaque being from the proximal three-quarters of axillary border of the scapula. In man the muscle has possibly a more extensive origin than in Orang, since Man's muscle originates from upper two-thirds of axillary border of scapula, while in my Orang it gained origin only from the upper half of this border of scapula. The human insertion is wider than that in Orang or Rhesus monkey.

Taken altogether, the Rhesus macaque seems to have the dominating force for lateral rotation, since its Deltoid fibres are relatively more powerful than those of Orang and Man, its Infraspinatus is comparatively bulkier than the human's, and its Teres Minor muscle possesses the greatest origin of all three.

The Orang's Deltoid fibres are more powerful than the human's, and its Infraspinatus muscle is somewhat more bulky than that of Man. The Teres Minor, however, seems to be relatively greater in Man than in Orang. Nevertheless, taking all three muscles together, the Orang and Man are about equal in their lateral rotating forces, the former being possibly slightly stronger.

So, summarizing the results obtained in the consideration of the various movements of the shoulder joint, one finds the following primates dominant in that particular action:-

Adduction	:	Man
Abduction	:	Rhesus macaque
Flexion	:	Rhesus macaque
Extension	:	Man
Medial Rotation	:	Man
Lateral Rotation	:	Rhesus macaque

Therefore, the actions in which each animal is strongest at the Shoulder Joint are:-

RHESUS: Abduction, Flexion and Lateral rotation:

MAN: Adduction, Extension and Medial Rotation.

The ORANG'S actions at the shoulder do not dominate the field of comparison in any one way: the strongest actions are:-

Abduction: Extension: Medial and Lateral
Rotation: Adduction and Flexion being the
two weakest actions.

From these results it is seen that the pronograde Rhesus monkey has abduction, flexion and lateral rotation as the relatively strongest and most important movements at the shoulder joint. Man, on the other hand, who has directly the opposite posture, namely, the erect posture, has directly the opposite movements most prominent at the shoulder, that is - adduction, extension and medial rotation.

The Orang has a semi-erect posture. His shoulder joint movements compare fairly closely to Rhesus macaque in abduction and lateral rotation, but they compare more closely to Man in extension and medial rotation. Thus it seems that, just as the Orang's posture is intermediate between the two extremes, so too, as the above results show, are his most dominant shoulder movements intermediate between the two extremes found.

This parallelism apparently indicates that some definite association exists between the characteristic posture adopted by an animal and the arrangement of the muscle ^{system} ~~system~~ involved. That is, the muscle mechanism employed is adapted and modified to satisfy the animal's requirements.

THE ELBOW JOINT: There are only two movements at the Elbow Joint:-

Flexion and
Extension.

The muscles bringing about Flexion are the Brachialis, the Biceps Brachii, the Brachio-radialis, and the flexor muscles of the forearm which attach to the medial epicondyle of the humerus. Muscles producing Extension at the elbow are the Triceps and the Anconaeus.

The Brachialis muscle varies very little between Rhesus, Orang and Man, in extent of origin and insertion. The only difference is that the muscle in rhesus monkey and orang might be considered a little more bulky than the human muscle. The Biceps Brachii likewise is very similar in all three, the only difference being the presence in Man of the lacertus fibrosus at the insertion. This is bound to assist flexion of the forearm, but it cannot have much to do with supination.

In Rhesus macaque and Orang the origin of the Brachio-Radialis muscle extends higher up the humerus than it does in Man. The flexor action over the elbow must, therefore, be relatively greater in Rhesus and Orang than in Man - not only because of the greater bulk of muscle, but also because of the greater leverage the muscle must have over the elbow-joint in these two animals. The flexor muscles of the forearm which attach to the medial epicondyle of the humerus must have a flexor action on the elbow joint which is relatively equal in all three.

Reviewing the flexor muscles of the elbow joint, the conclusion is arrived at that Man has the weakest set of flexors of the three. Actually, they must be all of about the same strength, but the less bulky Brachialis muscle and the smaller and more dis-

tolly placed Brachio-Radialis muscle in Man must tip the balance in favour of Rhesus and Orang. These latter two must be approximately equal to one another.

As far as the Lateral and Medial Heads are concerned, the Triceps muscle must be relatively equal in all three primates. But when considering the long head it is obvious that Rhesus and Orang muscles are far more powerful than that of Man, since, in the former two, this head arises not only from the Infra-Glenoidal tuberosity of the Scapula, but also from the edge of the lateral half of the axillary border of the Scapula, while Man's muscle arises solely from the infraglenoidal tuberosity. This necessarily makes the Triceps in Rhesus and Orang a more powerful extensor muscle than the human Triceps.

The other muscle of extension, the Anconeus is strongest in Man and Orang (in whom the origins and insertions are alike), and weakest in Rhesus monkey, for in him the origin, insertion and bulk of the muscle are all smaller relatively than in Man and Orang.

Thus considering Triceps and Anconeus together, one sees that the Orang has the strongest extensor musculature at the elbow, since its Triceps muscle is greater than Man's and equal to that of the Rhesus monkey, and its Anconeus is greater than Rhesus' and equal to Man's.

The superiority of the Rhesus' Triceps over that of Man more than makes up for the inferiority of its Anconeus muscle. So then Rhesus comes a very close second to the Orang, and Man takes last place possessing the weakest extensor mechanism of the elbow joint.

Rhesus macaque and Orang have about equal relative force for flexion and extension of the elbow joint, but they are much stronger than Man in both these movements. This means that they

have much greater power over the joint than has Man, and this would indicate that it is a more important joint in the Orang and Rhesus monkey than it is in Man. A glance at the habits and modes of progression of these two animals explain this. The elbow is a very important joint in the pronograde position of rhesus, and the Orang elbow plays a great part in the climbing of this animal. The importance of the elbow joint in the two arboreal types and the relative non-importance of this joint in Man can be forcibly brought out by imagining in what degrees some trauma, causing non-functioning of this joint, would impede the various methods of progression in the three animals.

- 4 -

The Radio-ulnar Joints allow two movements of the forearm -

Pronation and
Supination.

Some muscles assist in these movements in a secondary fashion, such as the Brachio-Radialis, Flexor Carpi Radialis, etc., but only those muscles whose main function is the control of these joints will be considered here. The muscles causing Supination are the Supinator and the Biceps Brachii.

The muscles causing Pronation are the Pronator Teres and Pronator Quadratus.

The origin of the Supinator muscle is strongest in Man, since in him it arises from the lateral ligament of the elbow-joint, from the annular ligament of the radius, and from a comparatively greater area of origin from the Ulna than it has in either Orang or Rhesus macaque. The insertion in the macaque, however, is more extensive^{ve} than either that in Man or in Orang. The Orang insertion is much the same as the human. If there are relatively the same number of fibres in the Rhesus muscle, in the Orang muscle, and in the Human muscle, then the Rhesus insertion must

entail a spreading out of the fibres and a thinning of the muscle. In Orang and Man the fibres are bunched more together to form a thicker muscle. The axis of the force of muscle passes through the centre of the area of insertion (provided the muscle inserts with a ^{uniform} ~~uniform~~ thickness), and since the area is more extensive in Rhesus monkey than it is in Orang or Man, this centre point will be further down the shaft of the radius than will the central points in Orang and Man. Now since this muscle acts on the proximal radio-ulnar joint, the nearer the central point is to this joint the stronger will be the action of the muscle, and the further away this point is from the joint the weaker the action will be. Thus, if this is the case, then the human and Orang muscle should be stronger than the rhesus muscle. Also, since the origin is greatest in Man, then the human supinator muscle must be relatively the most powerful of the three, with Orang a close second and Rhesus monkey last.

(However if in the Rhesus macaque the additional insertion distally into the radius is made up by additional muscle fibres, so that the total bulk of its muscle would be relatively greater than that of Orang or Man - then it must necessarily follow that it would be a stronger muscle with a consequent stronger action than the Orang or Human muscle. But this is unlikely, since the origin of the Rhesus muscle is relatively less than that in Man, and is by no means greater than that in Orang.)

The other muscle of supination is Biceps Brachii. This muscle presents very little difference in the three animals, the only difference being the presence of the Lacertus fibrosus band in Man, which cannot help supination of the forearm to any appreciable degree.

Considering the supinating forces, we see that though they nearly equal each other in Rhesus macaque, Orang and Man - Man

has a slightly better force, with Orang a very close second, while Rhesus monkey has relatively the weakest supinating force of the three.

Pronator Teres enjoys a more robust origin in Orang and Man than it does in Rhesus monkey - in the former two animals it arises by two heads of origin, while in the latter animal it arises by a single head (Humeral Head). The insertion of the muscle is most extensive in the macaque, occupying the middle one-third of the shaft of the Radius; less in Orang - occupying the second proximal quarter of the shaft of the radius, and least in Man, whose muscle insertion occupies only about one-sixth of the shaft of the radius just proximal to the middle of the shaft. If the muscle inserts equally over the area of its insertion, then the same argument used for the supinator must necessarily apply here to the pronator teres. Thus the axis of the force of the muscle passes through about the centre point of the area of insertion, and since the pronator teres muscle acts on the superior or proximal radio-ulnar joint, then the nearer this centre point is to the joint the greater will be the force of the muscle, and conversely, the further away this centre point is from the joint the weaker will be the action of the muscle. Considering the centre points of the insertions in Rhesus monkey, Orang and Man, we see that that of Orang is most proximal, while that of the Rhesus is most distal, Man being in between the two. Thus comparatively, the Orang muscle must have greatest pronating force, while the rhesus muscle has least, Man's muscle being intermediate. (This holds provided the muscle in each contains an equal number of fibres. This is probably so in Orang and Man, since both arise by two heads. As the Orang is slightly stronger in its deep head it might have even more fibres, which must then make this muscle still stronger. The rhesus muscle, arising only by one head, probably has not so many fibres as the other two, and

this makes it still weaker.

The Pronator quadratus has a relatively equal force in all three.

So reviewing the pronating muscles together it is obvious that the Orang enjoys the strongest pronating mechanism of the three, the Rhesus macaque the weakest pronating mechanism, and Man is in between the two.

So:

Supination : Man and Orang _____ Rhesus macaque

Pronation : Orang and Man _____ Rhesus macaque

These results fit quite well into the characteristic pictures of the three primates.

Rhesus monkey uses his upper limb primarily for support - so he does not require strong supinator and pronator mechanisms for his forearm.

The Orang uses his upper limb not only for climbing but also for manipulation so that supination and pronation become important movements, - and on studying the movements of the Orang's forearm, especially when climbing or hanging, it is apparent that pronation is even more emphasised than supination - which is according to the above findings. Man uses his upper limb mainly for manipulation, so supination and pronation are equally important, and this co-incides with what was found above, both movements being well developed.

- 5 -

At the Wrist Joint four movements are possible:

Extension,
Flexion,
Abduction (Radial deviation), and
Adduction (Ulnar deviation).

The muscles mainly concerned with Extension of the wrist-joint are the Extensors Carpi Radialis Longus and Brevis and the

Extensor Carpi Ulnaris. Those muscles having a secondarily extensor action on the wrist are the -

Extensor Digitorum,
Communis,
Extensor Digiti Minimi,
Extensor Pollicis Longus and the
Extensor Indicis.

Comparing the Extensores Carpi Radialis Longus and Brevis muscles in Rhesus monkey, Orang and Man, it is found that no significant differences exist between them, and therefore they must have an equal relative action in all three.

The Extensor Carpi Ulnaris muscle, however, is much stronger in Orang and Man than it is in the macaque, because in the former two the muscle gains origin from about half the length of the ulna - an origin which is completely absent in the Rhesus monkey.

Of the secondary muscles of extension at the wrist the Extensor Digitorum Communis and the Extensor Digiti Minimi are relatively much the same in Rhesus monkey, Orang and Man. The Extensor Pollicis Longus muscle has similar origin and insertion in all three, but the human muscle is comparatively larger and better developed than that in the macaque or that in Orang.

In Man the Extensor Indicis muscle inserts entirely into the index finger.

The insertion in Rhesus monkey and Orang is by two tendons which insert into the index and middle fingers. Actually this difference in insertions should have no effect on the action that the muscle has over the wrist-joint. The Rhesus and human muscles are not much different to one another, but by comparison the Orang muscle is larger and has a greater origin. It should have thus the strongest action on the wrist joint.

Reviewing the extensor muscles of the wrist-joint, it is seen that the Extensores Carpi Radialis Longus et Brevis, the Extensor Digitorum Communis, and the Extensor Digiti Minimi

muscles are relatively equal in all three primates concerned.

The Extensor Carpi Ulnaris is strongest in Orang and Man;

The Extensor Pollicis Longus is strongest in Man;

The Extensor Indⁱcus is strongest in Orang.

So the obvious result which emerges from this analysis is that the Rhesus monkey has the weakest extensor mechanism of the wrist of all three. Orang and Man have probably about equal force for extending the wrist.

The Flexor muscles of the wrist joint are the Flexor Carpi Radialis and the Flexor Carpi Ulnaris. Muscles which produce flexion at the wrist as a secondary action are the Palmaris Longus, the Flexor Digitorum Sublimis, the Flexor Digitorum Profundus and the Abductor Pollicis Longus.

The Flexor Carpi Radialis is approximately equal in force in Rhesus and Man, but in the Orang it is more powerful due to its far more extensive origin. (In Orang it enjoys an extensive radial attachment which is lacking in the muscles of the other two animals.)

The Flexor Carpi Ulnaris is very similar in Rhesus monkey, Orang and Man and no significant difference between them was noted.

In Rhesus macaque this muscle is found to attach to a remarkably elongated pisiform bone. But this elongation should be regarded in the light of a compensatory mechanism, because in the pronograde posture of the Rhesus monkey the wrist, being normally extended, would cause the Flexor Carpi Ulnaris to function at a mechanical disadvantage, and elongation of the pisiform acts as an extended lever which compensates for the disadvantage. As a result the muscle must function as well in the macaque as it does in Orang and Man.

The Palmaris Longus, likewise, shows no significant difference in the macaque, Orang or Man.

The Flexor Digitorum Sublimis is by far the weakest in the Rhesus monkey, for in this animal the muscle lacks the coronoid and the radial origins which are enjoyed by the Orang and the human muscle. In flexing the wrist joint the Orang muscle has about the same power as the human muscle.

The Flexor Digitorum Profundus muscle, though it varies in structure and insertion in the three, when taken as a whole, exerts a relatively equal flexor force on the wrist in the macaque Orang and Man.

The Abductor Pollicis longus muscle is relatively strongest in Rhesus macaque and Orang, and weakest in Man. This is so because, in the latter, the muscle has lost the substance of the Extensor Pollicis Brevis muscle, these two muscles being incorporated into the one belly in Rhesus monkey and Orang.

Thus, the Flexor Carpi Ulnaris, the Palmaris Longus and the Flexor Digitorum Profundus are muscles which show no great difference in Rhesus Monkey, Orang or in Man. The Flexor Carpi Radialis is strongest in the Orang. As far as the Flexor Digitorum Sublimis is concerned, the Orang is more powerful than the macaque, but is equal to Man. Abductor Pollicis Longus in the Orang is relatively stronger than it is in Man, but is equal to its counterpart in Rhesus monkey.

Taken as a whole, therefore, the Orang appears to possess a much more powerful muscular equipment with which to flex his wrist joint than does Rhesus macaque or Man. Of these latter two, Man is probably a little more powerful than the Rhesus monkey because the superiority of the human Flexor Digitorum Sublimis probably outweighs the superiority of the Rhesus' Abductor Pollicis Longus muscle.

The next movement at the wrist is that of Abduction or Radial deviation. This is brought about by the Flexor Carpi Radialis, the Extensor Carpi Radialis Longus and Brevis, the Abductor Pollicis Longus, the Extensor Pollicis Brevis, and the Extensor Pollicis Longus.

The Flexor Carpi Radialis, as has been mentioned above, is strongest in the Orang due to its more extensive origin, which includes a considerable attachment to the Radius. It is approximately equal in Rhesus monkey and Man.

The Extensores Carpi Radialis Longus et Brevis are relatively equal in all three primates.

The Abductor Pollicis Longus is strongest as such, in Rhesus macaque and Orang, as has been explained above, but when considering the Extensor Pollicis Brevis (which only appears as such in Man) along with it, then the conclusion must be drawn that the abducting force is relatively equal in Rhesus monkey, Orang and Man.

The Extensor Pollicis Longus muscle is similar in origin and insertion in all three, but the human muscle is larger and better developed than the Rhesus and Orang muscles, so presumably it has the greatest force.

The Extensores Carpi Radialis Longus et Brevis and the Abductor Pollicis Longus (taken together with the Extensor Pollicis Brevis in the case of Man) are muscles which are comparatively equal in all three primates under consideration.

The only real differences lie with the Flexor Carpi Radialis and the Extensor Pollicis Longus muscles. In the former, the Orang is the strongest; in the latter Man is the most powerful. But the superiority of the Orang's Flexor Carpi Radialis is greater than the superiority of the human Extensor Pollicis Longus muscle.

Reviewing the abducting forces of the wrist, the Orang has the predominating force of the three, Man taking a slightly inferior position, while Rhesus monkey definitely presents the weakest abducting muscular force at the wrist.

The final movement at the wrist-joint is that of Adduction. This is performed by the action of only two muscles which must function simultaneously for the best result to be obtained. They are the Flexor Carpi Ulnaris and the Extensor Carpi Ulnaris. The former muscle shows no significant differences in either the macaque, Orang or Man, but the latter muscle enjoys a far more extensive origin in Orang and Man than it does in Rhesus monkey, and consequently it should have a more powerful action in these two animals. As a whole, therefore, the Rhesus probably possesses the weakest adducting force of the three, while Orang and Man are approximately equal to one another.

Thus, the strongest at the various movements at the wrist are:-

Extension	:	Orang and Man
Flexion	:	Orang
Abduction	:	Orang
Adduction	:	Orang and Man

The Orang is seen to be most powerful in all four movements at the wrist, flexion being the movement in which the dominance is most marked.

Man is very close to the Orang in Extension, Abduction and Adduction.

The Rhesus macaque is weakest of the three in all movements.

The Rhesus monkey, in his characteristic pronograde mode of progression, does not require any special movement at the wrist, since the upper limb is used almost entirely for support alone.

The Orang uses his upper limb as an instrument for climbing, for hanging, for progression and for manipulation. He has strong

movements at the wrist ther fore, especially flexion, for this movement is most necessary in his mode of climbing or hanging, where the weight of the whole body is often suspended from one hand alone.

Man uses his hand and wrist for manipulation and for more specialised movements than does the macaque, and as the above results indicate, he has relatively stronger wrist movements than macaque. Flexion is not as powerful as in the Orang, but this may be due to his habits and mode of progression which do not entail climbing and hanging from branches, etc.

- 6 -

The Metacarpo-phalangeal joints of the Medial four digits exhibit four movements:

Extension,
Flexion,
Abduction and
Adduction.

The Extension at these joints is brought about by the Extensor Digitorum Communis, the Extensor Digiti Minimi and the Extensor Indicis.

The Extensor Digitorum Communis is a muscle which compares closely in Rhesus macaque, Orang and Man, and has an equal action in each of the animals. The Extensor Digiti Minimi muscle gives rise to two tendons of insertion in Rhesus monkey and Orang - supplying digits four and five. In Man there is only one tendon of insertion, this supplying the fifth digit. Similarly, in Rhesus monkey and Orang the Extensor Indicis muscle inserts by two tendons - supplying digits two and three, while in Man the insertion is made by one tendon which supplies digit two. All four medial metacarpo-phalangeal joints in Rhesus macaque and Orang, therefore, have two sets of extensor tendons. In Man

only the second and the fifth digits are supplied in this way, the third and fourth having only one set of extensor tendons.

The conclusion that suggests itself from this arrangement is that, while the fingers in Rhesus monkey and Orang must function together - almost as one unit, in Man the extensor force has become somewhat divided, which allows a much wider range of independent movements in the hand.

As a whole, therefore, the Rhesus macaque and Orang metacarpo-phalangeal joints are stronger and better equipped for extension than are those of Man. Of Rhesus monkey and Orang, the latter appears to have the relatively stronger muscle system (because of its more extensive origin and greater bulk) and so the Orang must be the strongest of the three at extension, with Rhesus a close second, and finally Man last.

Flexion is achieved by the Flexor Digitorum Sublimis, Flexor Digitorum Profundus, the lumbricals and the Interossei.

The Flexor Digitorum Sublimis is strongest in Orang and Man, since in these two the muscle has a Coronoid and a Radial origin not enjoyed by the Rhesus' muscle. The Flexor Digitorum Profundus mass is probably of equal relative force in Rhesus and Man, but it must be stronger in Orang, since in this latter animal the whole muscle mass supplies only four digits while in the former two animals, its force is divided over five digits.

In Rhesus macaque and Man the Lumbrical muscles are comparatively stronger than in Orang. This is so, because in the former two, these muscles arise by two heads (from the sides of adjacent tendons) whereas in the Orang they arise solely by one head of origin. The only difference between the Rhesus and the Human muscles is that the lumbrical for the middle finger arises by two heads in Rhesus monkey and only by one head in Man.

The Interossei are about of equal strength in all three

animals.

Thus, considering the true flexors of these joints (viz. the lumbricals and interossei) the rhesus monkey and man appear relatively more powerful than the Orang. When, however, the secondary flexor muscles are included - the Flexores Digitorum Sublimis et Profundus - then the balance shifts in favour of the Orang, with Man second and Rhesus last.

Abduction is brought about by the Dorsal Interossei and, as far as the second and third digits are concerned, by the first and second lumbricals. The dorsal interossei are about equal in all three primates: the two lumbricales are relatively stronger in Rhesus macaque than in Orang or Man. So abduction must be approximately equal in the Macaque, Orang and Man, with Macaque possibly slightly stronger in digits two and three than the Orang and Man.

Adduction is performed by the Palmar Interossei, the Contrahentes, and as far as the fourth and fifth digits are concerned, the third and fourth lumbrical muscles.

The Palmar Interossei appear about equal in force in all three animals. The Contrahentes appear normally only in Rhesus - not in Orang or Man. The third and fourth lumbricals are relatively weaker in Orang than in Rhesus monkey or Man, because the muscles arise simply by one head, while in the other two primates they arise by two heads.

On account of the presence of the Contrahentes the Rhesus monkey is the strongest at adducting the fingers.

The proximal interphalangeal joints have only two movements: extension and flexion. Extension is brought about by the Extensor Digitorum Communis, assisted by the interossei and lumbricals. These three muscle groups are equal relatively in

the Macaque, Orang and Man - the only slight difference being that the lumbrical muscles of the Orang are the weakest of the three, since they arise solely by one head, while these muscles of Phebus and Man arise by two heads. This causes the Orang to have a slight disadvantage at extension when compared with Phebus monkey and Man.

Flexion is brought about by Flexor Digitorum Sublimis and Flexor Digitorum Profundus. The former muscle is by far the strongest in Orang and Man, since in these animals it enjoys a coronoid and radial origin - which Phebus monkey lacks. Orang is stronger than Man because the tendons of insertion in Orang insert into the middle of the shafts of the intermediate phalanges of the medial four digits - not, as in Man, into their bases. This arrangement must give the Orang muscle a great mechanical advantage. The Flexor Digitorum Profundus, as has been stated before, is strongest in the Orang - Man and Phebus monkey being about equal to each other, but being much weaker than the Orang. Therefore, when Phebus monkey, Orang and Man are compared, the Orang is found to possess the outstandingly dominant force for flexion of the proximal interphalangeal joints.

The distal interphalangeal joints have likewise only the two movements of Extension and Flexion.

The extensor force is exactly the same as with the proximal interphalangeal joints. The force producing flexion is the Flexor Digitorum Profundus muscle. This is relatively most powerful in the Orang. Phebus monkey and Man are similar to each other in force.

Reviewing the movements of the fingers, it is apparent that the Orang has by far the greatest flexor force of the three primates under consideration. This is as would be expected since this animal utilizes the medial four digits a great deal

for hanging from branches, relying completely on their flexor force to support his whole body.

At the Metacarpo-phalangeal joints the Extensor forces appear similar in Orang and Rhesus monkey and weakest in Man. Distal to this joint Rhesus is relatively the strongest at extension - a conclusion to be expected in the pronograde mode of progression in which the hand is used as a fore-foot.

Abduction of the fingers is approximately equal in Rhesus macaque, Orang and Man, it possibly being slightly stronger in the macaque in digits two and three. Adduction of the fingers is strongest in Rhesus.

Man is found to possess the best developed Thumb of the three primates, Rhesus also having a well developed but smaller Thumb, while in Orang this digit is poorly developed and even degenerate. However, in all three the Thumb is capable of the same movements, these being five in number:-

1. Extension is brought about by Extensor Pollicis Longus muscle in all three primates, this muscle being best developed in Man.

Man has an added strength at extension in possessing that essentially human muscle, the Extensor Pollicis Brevis.

2. Flexion is carried out by Flexor Pollicis Longus and Flexor Pollicis Brevis muscles. The former muscle is absent in the Orang, is present in Rhesus monkey and Man, and is relatively stronger in Man. The flexor pollicis brevis muscle is weakest in Man, since in him it appears to represent only about half the muscle belly as found in Rhesus monkey and Orang.

As a whole, Man enjoys the strongest and also the most differentiated flexor force of the three, since in him the long flexor muscle is an entirely separate and distinct structure in the deeper layer of the flexor aspect of the forearm, and the short flexor muscle is reduced to a single belly of muscle with a single origin and a single insertion.

3. The Abductor Pollicis Longus and Abductor Pollicis Brevis are the muscles responsible for abduction of the thumb. The ^{first} muscle is weakest in Man because the human muscle belly has been reduced since the Extensor Pollicis Brevis Muscle has divided off from it. The Abductor Pollicis Brevis is approximately equal in all three primates. This results in Man being relatively weaker at abduction than Rhesus monkey or Orang.
4. Adduction is performed by the Adductor Pollicis muscle, which though it displays differences in the three primates, ultimately produces an effect about equal in all three.
5. Opposition is brought about by the Opponens Pollicis muscle, which has about the same relative force in all three.

Man's thumb, as the above analysis indicates, is relatively strongest in Flexion and Extension and weakest in Abduction. It is not superior in force in adduction or Opposition, but seems to be equal to these movements in Rhesus monkey and Orang, this being a little surprising, especially in regards ^{to} Opposition, since it

would seem to be to Man's advantage to have possessed a hypertrophied opposing mechanism.

- S U M M A R Y -

Regarding the upper limb of *hesus* as a whole, it is clear that though this is a generalised primate, it has its muscular systems arranged so as best to suit its pronograde posture and its arboreal existence. The examination of the musculature of the shoulder girdle shows that this animal has, compared to the Orang and Man, a stronger mechanism for drawing the shoulder girdle backwards and forwards. Its shoulder joint is greatest at Abduction, Flexion and lateral rotation, and its elbow joint is much stronger in both its movements than in Man. It should be noticed that these arrangements are those that would be most useful for a pronograde arboreal existence. The radio-ulnar joints are found not to be exceptionally strong at any of their movements and associated with this is a comparatively weak wrist joint. The hand is adapted rather for extension than for flexion. These findings fit in with the role of the forearm, wrist and hand in the pronograde position, as these play no very special part, except that of support.

The Orang's shoulder girdle is found best equipped for upwards and downwards movements - actions which are the most useful for the Orang's climbing habits. The shoulder joint is found to have no outstandingly specialized movements, but its mechanisms lie between those found in the pronograde macaque and those found in upright Man. The elbow joint is equipped with very powerful muscles - relatively much more powerful than Man's corresponding musculature.

The Radio-Ulnar joints are stronger at pronation than at supination, and the wrist is found to have all its movements relatively strongest in this animal. The hand has an extremely strong flexor mechanism. These findings are all as one would expect in the Orang, which relies to such a great extent on his upper limbs in his particular mode of progression.

Man is found to have the downwards and backwards movements of the shoulder girdle best developed. These movements fit in well with the associated upright posture and with man's "square" shoulders. Adduction, extension and medial rotation are the strongest movements of the shoulder joint, and are found to be directly opposite to those movements strongest in pronograde Rhesus' shoulder joint. The elbow musculature is much weaker than in Rhesus or Orang, relatively speaking, and this can be explained by the loss of the former functions of the upper limbs as limbs of support and as organs of progression. Supination is relatively stronger than pronation, and the wrist has extension, abduction and adduction as the outstanding movements.

The hand is found to have special adaptations for a wider field of independent movement. The most marks of these adaptations are the limiting of the insertions of Extensor Digiti Minimi and Extensor Indicis to the little and index fingers respectively, and the generalized enlargement of the thenar eminence, together with a very well developed thumb.

DISCUSSION ON THE LOWER LIMB MUSCLES OF THE
RHESUS MACAQUE, ORANG AND MAN.

As with the Upper Limb, the Lower Limb may be conveniently divided into sections, the following being the most natural divisions:-

- 1): the hip joint,
- 2): the knee joint,
- 3): the ankle joint, and
- 4): the foot and its associate joints.

The discussion will concern itself with each of these sections in this order.

HIP JOINT: Thus, commencing with the Hip Joint, it is found that there are six distinct movements to be considered:

- 1): Adduction,
- 2): Abduction,
- 3): Flexion,
- 4): Extension,
- 5): Medial rotation, and
- 6): Lateral rotation.

There are a large number of muscles which bring about adduction at the hip joint, either as their main function or as secondary actions. The Adductor group of muscles, consisting of the Magnus, Brevis, Longus and Minimus, form that group which has adduction as its main function. The lower fibres of the Gluteus Maximus, the Quadratus femoris, Obturator externus, Pectineus, Sartorius and Gracilis also assist in adduction in varying degrees.

In the rhesus macaque the origin of the Adductor Magnus spreads relatively far more anteriorly along the pubis, than it does in Man, extending almost as far as the anterior end of the symphysis pubis, while in Man the origin does not even extend as far as the posterior part of the symphysis. However, the origin of the human muscle from the ischial tuberosity and posterior part of ischium has become very much stronger than in rhesus monkey. This indicates a posterior displacement of the origin of this

muscle in Man to accommodate his orthograde posture. Taking this into account there does not seem to be a great deal of difference between the macaque origin and the human origin.

It may be thought that as the rhesus muscle has a considerable origin from a position so near the midline of the body as the symphysis pubis - which Man has not - it should have a greater adducting power due to the mechanical advantage so gained. But on comparing the rhesus macaque pelvis with that of Man, it is seen that the former is much narrower than the latter and, therefore, the acetabula are really nearer the midline than they are in the human pelvis. The distance between the joint and the muscle origin must be about the same in both animals, that is, the leverage of the muscle must be about equal both in Rhesus monkey and Man.

The insertion of the human muscle is relatively greater than the insertion existing in the macaque. The former proceeds as far up the femur as the quadrate tubercle, and extends distally as far as the adductor tubercle, while the rhesus muscle confines its attachment to the linea aspera alone. The rhesus muscle lacks the human ischio-condylar portion and it therefore has not the attachment to the medial supracondylar line and adductor tubercle.

Considering that the origin of the muscle is comparatively very similar in rhesus macaque and Man, as far as function is concerned, the somewhat greater insertion of the human muscle probably gives it a relatively stronger adducting force than the corresponding muscle in rhesus.

The origin of the Orang muscle is very similar to that of Man, except that it extends more medially, becoming adjacent to the posterior portion of the symphysis pubis. However, it does not extend so far forwards along the symphysis as does the

rhesus muscle. Posteriorly, the orang muscle (in my specimen) gains a considerable origin from the medial border of the common tendon of the hamstring muscles, an origin not found in rhesus or Man. The origin of the orang muscle appears therefore, to be relatively a little more extensive than the Human muscle. The insertion of the muscle in the orang is almost identical with the insertion of the human muscle. The acetabulum of the Orang is relatively further from the mid-line than in Man's, so in addition, Orang has a considerable mechanical advantage in having a longer lever here than Man.

Therefore, as a whole, the orang muscle appears to be definitely stronger than the human muscle, which in turn is relatively stronger than the rhesus muscle.

The origin of Adductor Longus is almost identical in rhesus monkey and Orang, being from the cranial border of the pubis, lateral to the symphysis, between the origins of gracilis and pectineus. In Man this origin has moved backwards somewhat, - off the superior border of the pubis on to the anterior surface of the body of the pubis in the angle between the crest and the symphysis, this displacement being appropriate to Man's orthograde posture. The insertion, in rhesus macaque, is into a considerable portion of the upper part of the linea aspera, in Man into the middle two-fourths of the linea aspera, and in the Orang into the third-quarter of the linea aspera. Since the muscle inserts fairly evenly, the middle point of the line of insertion can be taken to represent the point of force through which the muscle acts on the femur. It is relatively nearest the hip joint in rhesus; next is Man's muscle whose middle point of insertion is the middle of the linea aspera; and finally, the Orang's muscle is inserted furthest from the hip joint.

The Orang's muscle has consequently a greater ad ucting

force on the hip joint than either the human or the rhesus muscle. The human origin is a little further from the acetabulum than the origin of the rhesus muscle, so it should have greater leverage at the hip joint, due both to its origin and to its insertion, than the rhesus muscle. The orang origin is more similar to the origin of the human muscle than the rhesus muscle and, since it has greater leverage by means of its insertion, it should either equal the force of the human muscle, or, as is more likely, exceed it somewhat. The result, therefore, is that the Adductor Longus muscle is relatively strongest in the Orang, next strongest in Man, and finally, it is decidedly weakest in the rhesus monkey.

The origin of the Adductor Brevis, like the other muscles of this group, has been displaced backwards on the pubis in Man as compared to the origin of the muscle in rhesus monkey, this change again being appropriate for Man's upright posture. In rhesus the muscle arises from the pubis deep to the adductor longus and directly ventral to the obturator foramen. In Man it arises from an elongated oval area on the front of the body and upper part of the inferior ramus of the pubic bone. The rhesus muscle inserts into the upper quarter of the linea aspera, whereas the human muscle inserts more extensively upwards - into the upper quarter of the linea aspera as well as the lower two-thirds of the line leading from the lesser trochanter to the linea aspera. Thus, taking the middle point of the line of insertion as the point through which the force of the muscle acts on the femur, it is seen that the point of the human insertion is a little nearer the hip joint than is the corresponding point of the macaque insertion.

Considering the insertion therefore, it seems that the rhesus muscle should have greater leverage on the hip joint than

the human muscle. However, to counter-balance this advantage, the other lever concerned - the distance between the muscle origin and the hip joint, is a little greater in Man than it is in rhesus macaque, so that the nett result is that this muscle has probably about an equal relative force in the macaque and in Man.

The Orang origin is placed more forwards or ventrally on the pubic bone than is the origin of the human muscle - resembling the origin of the Thesus' muscle. However, it has a more extensive origin than the Rhesus muscle and proceeds further backwards, - the actual origin being from the pubic bone, on its ventral surface, extending from the symphysis pubis to just deep to the origin of the Adductor Longus. Its origin lies deep to the origins of Gracilis, Adductor Accesorius and Adductor Longus. Deep to it lies the Obturator Externus. It does not extend down on to the inferior ramus as it does in Man. So it seems that the origin of the Orang's muscle is somewhat intermediate between the rhesus and human, and is relatively greater than either of them. The insertion of the Orang muscle is into the posterior surface of the upper one-quarter of the shaft of the femur, between the insertions of pectineus medially and that of Adductor Magnus laterally.

The insertion thus resembles that found in Man and Rhesus macaque. Since the relative distance between the origin of the muscle and hip joint tends to resemble that of the human condition rather than that of the rhesus monkey and, since the origin is slightly larger than that of Man, it can be assumed that this muscle may be a somewhat stronger adductor in the Orang than it is in Man or Rhesus.

The Adductor Minimus (Adductor Accessorius) is a separate muscle both in Rhesus monkey and Orang, but it is usually

incorporated in the Adductor Magnus in Man. When it does occur separately in Man it arises from the lower part of the pubic bone - that part occupied by the upper fibres of Adductor Magnus - and it inserts into the femur proximal to the linea aspera. In Rhesus monkey the muscle origin is placed far more posteriorly compared to Man's or Orang's muscle. It arises from that part of the ischium caudo-ventral to the Obturator foramen and it inserts upon the lateral part of the linea aspera over approximately the first-quarter of the femoral shaft.

In the few human cases where the muscle exists separately, it must be about relatively equal to that in the rhesus macaque for the greater leverage obtained by Man due to the position of the origin is counter-balanced by the greater leverage obtained by the insertion of the rhesus muscle.

In the Orang this Adductor Accessorius is a separate and well developed belly of muscle which arises from the medial portion of the pubic crest and from the lateral portion of the whole of the symphysis pubis. It lies immediately deep to the Gracilis and arises adjacent to it. It is, therefore, much more ventral than the rhesus origin and is also more ventral than the human origin. The insertion is by aponeurosis into the linea aspera, half-way down the thigh, being in close apposition to, and actually inserting with, the adjacent portion of Adductor Magnus. The insertion of the Orang muscle has, therefore, relatively a greater leverage than the rhesus muscle, and it is also greater than that enjoyed by the human muscle. The origin, as seen above, is considerably greater in extent and in leverage in Orang than in the macaque, since the Orang origin is comparatively further from the hip joint than is the macaque origin. The Orang muscle then has, in comparison, probably much greater adducting force than the rhesus muscle, and this

latter is in turn greater than the human in whom, in the majority of cases, it is lacking. But in the few cases where the muscle is separate in the human, it probably is equalled by the rhesus muscle.

The lower fibres of the Gluteus Maximus take part in adducting the femur towards the midline, but, despite the great increase in bulk in the human muscle, and also less markedly in the Orang, as compared to Phebus' muscle, the lower fibres which bring about adduction have not altered to the same degree as the rest of the muscle. The human muscle is the largest and heaviest of the three, the Phebus' muscle being the smallest and lightest. The human and orang adducting fibres are about equal, since they both arise from the lower posterior part of the iliac crest and from the sacrum and coccyx. But the human muscle has stronger attachments than the orang's muscle, since it has greater attachment to the ilium and also an attachment to the sacro-tuberous ligaments. The Orang, however, has a powerful muscle, which is really the lower part of the Gluteus Maximus, lying in close relationship to the origin and upper part of Biceps Femoris, arising from the ischial tuberosity and common hamstring tendon. It inserts into the lateral inter-muscular septum (especially in its lower half) and also into the adjacent Fascia Lata. This portion probably makes the adducting strength of the Gluteus Maximus of the Orang at least equal to, and very likely greater than, the adducting strength of the human muscle.

The rhesus muscle which arises only from the transverse processes of the upper two caudal vertebrae and from the dorsal fascia over the sacrum, is very much weaker, relatively, than either the orang or the human muscle.

Thus the adducting power of the lower fibres of Gluteus

Maximus is about equal in Orang and Man (probably stronger in the former) and definitely weakest in the rhesus monkey.

The Quadratus Femoris is very much the same in all three animals, the only feature of difference being that Man's muscle enjoys insertion into a special quadrate tubercle, a bony landmark not distinct in the rhesus macaque or the Orang. The force of adduction must be, relatively, very nearly the same in Man, Orang and rhesus monkey.

On examining the origin of the Obturator Externus in each of the three primates, it is seen that in the human and in the orang the origin is placed more ventrally and medially as compared to the origin of the rhesus muscle. This rhesus muscle arises from the lateral border of the obturator foramen and its membrane, backwards along the superior ramus of the ischium and the cranial margin of the ischial tuberosity and forwards along the pubis almost as far ventrally as the symphysis. In Man the muscle arises from the surfaces of the pubic bone and ischium, which form the inferior half of the obturator foramen, and from the corresponding portion of the superficial surface of the obturator membrane. The Orang muscle has a similar origin to the human's muscle. The insertion is the same in all three: into the trochanteric fossa of the femur. The fact that the rhesus muscle arises so far back and laterally causes it to lose some of its power as an adductor, but causes it to gain power as a lateral rotator of the hip joint, as compared with the muscle in the other two animals. Conversely, in Man and Orang the forwards and medial position of origin increases the adducting power of the muscle, but renders it relatively weaker as a lateral rotator. So as an adducting force, the Obturator Externus is equally strong in Man and Orang, but is weaker in the rhesus macaque.

The Pectineus enjoys a much more powerful origin, comparatively speaking, in Man than it does in rhesus monkey. In this latter animal the muscle arises from the most cranial border of the pubis immediately above the obturator foramen. In Man the muscle arises from the sharp anterior portion of the pectineal line of the pubis and the triangular surface of the pubic bone in front of that line, and also from the pectineal portion of the fascia lata which covers it. The insertions, however, differ considerably. The rhesus muscle has a tendinous insertion upon the linea aspera for about one-third of the length of the femoral shaft, whereas the human muscle inserts only into the proximal half of the line from the lesser trochanter to the linea aspera. Thus it follows that the more distal insertion of the rhesus muscle must give it better leverage at the hip joint than the human muscle can enjoy. This superiority is offset somewhat by the relatively greater origin of the human muscle, but this would not be sufficient to cause the human muscle to have the greater power over the hip joint. The orang origin is less sturdy than the human muscle origin and its insertion is almost identical to the insertion of the human muscle. It appears, therefore, that the pectineus in the rhesus macaque is possibly a little greater in power than either the human or the orang muscle, the muscle of the latter being probably the weakest of the three.

The Sartorius is necessarily a weak adductor of the thigh, and since there is no outstanding difference in the muscle as found in the macaque, orang and man, it may be concluded that it exerts approximately the same relative adducting force on the hip joint in all the three primates.

The Gracilis has comparatively a slightly greater origin in Man than in rhesus monkey. In the former, this muscle arises

by a tendon from the lower half of the edge of the symphysis pubis and for a similar distance along the border of the pubic arch, whereas in the latter it arises only from the lateral margin of the cranial half of the symphysis pubis. (Here again is seen the backwards displacement group, this probably being an adaption for the orthograde posture). The insertions are similar in Man and Rhesus monkey. The adducting power appears, thus, to be relatively a little greater in Man than in the macaque. The Gracilis muscle of the Orang, however, greatly out-strips both the human and the Rhesus muscle. Its origin is approximately 2-3 times as great in extent, relatively, as the Rhesus muscle origin. It arises from the medial half of the upper border of the pubic crest, from the lateral margin of the Symphysis Pubis in its whole length, and finally from the anterior or medial portion of the ischio-pubic ramus. The bulk of the orang muscle is also far greater than that of the human or Rhesus muscle. The insertion in the orang is a little more distal on the tibia than in man or Rhesus monkey, being for the major part into the upper second quarter of the shaft of the tibia. In addition it has a very extensive insertion into the deep fascia over the whole of the medial surface of the leg.

Thus the Gracilis of the Orang is by far the strongest of the three, while that of the Rhesus macaque is probably the weakest.

Reviewing now the muscles bringing about, and assisting in, adduction at the hip, it is seen that the Orang is relatively the most powerful in the Adductor Magnus, Adductor Longus, Adductor Brevis, Adductor Accessorius (or Adductor Minimus) and Gracilis muscles, which group forms the chief adducting force at the hip. Regarding the lower fibres of Gluteus Maximus and

the Obturator Externus muscle, the Orang and Man are about relatively equal in force, with Rhesus monkey definitely weaker. In the Quadratus Femoris and Sartorius muscles the adducting force is approximately equal in all three animals. Thus it is obvious from the above that the Orang has undoubtedly greater adducting power at the hip than either Man or Rhesus monkey. The only discordant note in an otherwise harmonious picture is that the Pectineus is strongest in the Rhesus but weakest in the Orang. Despite this, however, the Orang must still maintain relative superiority at Adduction.

Man appears to be relatively stronger at adduction than rhesus macaque, since his Adductor Magnus, Adductor Longus, lower fibres of Gluteus Maximus, Obturator Externus, and finally Gracilis are all stronger than the corresponding muscles in macaque monkey. Rhesus monkey is about equal, relatively, to Man as far as the Adductor Brevis, Quadratus Femoris and Sartorius muscles are concerned. With the Adductor Minimus and Pectineus muscles the rhesus appears to be comparatively stronger than Man, but this does not make up for all the weaknesses of its other adducting muscles.

The relative strengths at Adduction of the hip joint, therefore, are in this order:-

- (1): Orang,
- (2): Man,
- (3): Rhesus macaque.

The next movement at the hip joint to be examined is that of Abduction. The main muscles which bring about abduction are the Gluteus Medius and the Gluteus Minimus. Tensor Fasciae latae assists in the movement. When the limb is flexed the Piriformis and Obturator Internus muscles assist in abduction. The Scansorius, which appears only in the Orang, gives considerable aid in abduction, working closely with the Gluteus Minimus.

The origin of the Gluteus Medius is comparatively greater in the macaque than it is in Man. In the rhesus monkey the muscle occupies most of the gluteal fossa of the ilium. Origin is from the deep surface of the dorsal fascia, from the superficial surface of the deep fascia over the sacrum, from the dorsal border of the ilium and from the acetabular border of this bone where it is fused with the origin of the tensor fasciae latae. In Man the muscle arises from (i) the dorsum ilii, between the iliac crest and posterior gluteal line above and anterior gluteal line below, and (ii) from the strong fascia lata covering the surface anteriorly.

The Orang origin is still more extensive than the rhesus origin. It arises from the whole of the dorsal surface of the wing of the ilium (which is comparatively much greater in size than that in rhesus) between the Greater Sciatic Notch, the anterior superior iliac spine and the iliac crest, and from the tough fascia covering it. The insertion of the muscle is very similar in all three primates, that of Man however, being somewhat specialised in that it inserts also into a diagonal line on the lateral aspect of the greater trochanter, the anterior fibres inserting furthest down. The Orang insertion is similar to that in the human, but is not so well differentiated. The greater bulk and greater origin of the muscle in Orang causes the muscle in this animal to be relatively stronger in action than the corresponding muscle in rhesus monkey or that in Man, and between the latter two, the rhesus muscle is probably the stronger.

On examining the Gluteus Minimus quite a different state of affairs is found. The muscle is relatively greater in bulk and in origin in Man than in the macaque. In the latter the muscle arises from the caudal half of the ilium, chiefly from the

dorsal border, and also partly from the fasciculi of the ischio-caudalis. In Man the origin of this muscle has extended anteriorly towards the anterior superior iliac spine and upwards well on to the dorsal surface of the wing of the ilium, occupying a little less than half this surface. It is limited between the anterior and inferior gluteal lines. The insertion is similar in both, but that of Man extends forwards on to the anterior surface of the greater trochanter, this resulting in very little change of abduction force, but increasing the power of medial rotation (and control) over the hip joint. The Orang muscle though having a considerably larger origin than the rhesus muscle, is not yet as great in extent or in bulk as the human muscle. It is intermediate between the rhesus at one extreme and man at the other extreme, but it is definitely nearer the human conditions than those found in the rhesus monkey. The origin of the orang muscle when compared with the rhesus muscle origin, is seen to have moved anteriorly towards the anterior superior iliac spine, and also a little upwards. Its actual origin is from the middle half of the bony border of the Greater Sciatic Notch continuing down to the ischial spine, and from a large area of bone adjacent to this, extending laterally as far as the Scansorius. However, the origin has not extended so far cranial-wards as has that of Man. The insertion is very similar in Orang and Man.

Thus, the Gluteus Minimus is relatively strongest in Man, followed by the Orang and is relatively weakest in rhesus monkey.

The Scansorius is a typically Orang muscle, appearing only very occasionally in the rhesus monkey and very seldom in Man. It has been described in Man by Testut, but this must be regarded as a very rare anomaly. The muscle has close association with the gluteus medius and minimus, especially with

the latter. It arises from the most anterior portion of the dorsum of the ilium extending from the level of the Anterior Superior Iliac Spine downwards to just above the upper lip of the Acetabulum. It inserts into the upper antero-lateral corner of the Greater Trochanter of the femur.

The ^TTensor Fasciae Latæ in rhesus arises from that part of the fascia coming from the anterior superior iliac spine, and from the acetabular border of the ilium between the minimus gluteus medius and sartorius. The muscle fibres disappear in the fascia lata at about the middle third of the thigh. The upper part of the muscle is fused with the gluteus maximus. In Man the muscle arises from the iliac crest and dorsum illi just lateral to the anterior superior iliac spine, and from the fascia covering its lateral surface. It is inserted distal to the greater trochanter of the femur, into a splitting of the fascia lata, and many of its fibres are continued into the ilio-tibial tract. In Man the muscle has become a much better developed entity. It is a quite separate belly of muscle, no longer fused with the gluteus maximus as in the rhesus, though there still exists the close relationship in the insertions of these two muscles. It has now gained a definite bony origin, this being associated with the increase in size and importance of the muscle in Man. The insertion of the bulk of the muscle is higher in the thigh in Man than is the case in the macaque. In the rhesus monkey the action of the muscle is simply to tighten the fascia lata and to assist in flexion of the hip. In Man, due to his upright posture, the action is more involved: the muscle assists in abduction, flexion and medial rotation of the thigh, but its most important action is exerted as an extensor of the knee joint through the ilio-tibial tract,

which it draws forwards as well as upwards, so counteracting the backwards pull of the gluteus maximus. This muscle is usually completely absent in the Orang.

The Piriformis and Obturator Internus act as abductors only when the limb is flexed, so that they will come into play most often in the rhesus monkey due to his pronograde posture, less often in the Orang, and least of all in the Human because of his orthograde or upright posture.

Considering the main abductors of the thigh (viz. Gluteus Medius, Gluteus Minimus and Scansorius) it is seen that the Orang's Gluteus Medius is relatively the strongest, and Man's muscle is the weakest. However, the human Gluteus Minimus is definitely the most powerful, with that of the Orang second and the rhesus muscle weakest. Now, taking the Gluteus Medius and Minimus together, the Orang's appears to be a more powerful combination than Man's, since it has the most powerful Gluteus Medius together with a Gluteus Minimus which is almost as powerful as Man's Gluteus Minimus, while Man has the most powerful Gluteus Minimus combined with relatively the weakest Gluteus Medius. The macaque combination is the weakest of the three, consisting of the weakest Gluteus Minimus, with only an intermediate Gluteus Medius. The Scansorius appearing only in the Orang confirms his superiority over Man at abduction of the hip joint. The tensor fasciae latae muscle is absent in orang, but present in Man and rhesus monkey, it being stronger in the former. This increases the power of abduction in Man and macaque and reduces the relative superiority of the Orang in this movement. The relative power of abduction at the hip is thus greatest in the Orang, followed closely by Man, and finally it will be weakest in Rhesus monkey. If the hip is flexed in

the macaque - as is usually the case - then the piriformis and obturator internus muscles come into play and the rhesus' force increases till it probably equals or even supercedes Man's abducting force.

The Orang probably uses these two accessory muscles of abduction far more than Man, but naturally not as much as the rhesus monkey. So the relative strength for abduction at the hip is greatest in (1) Orang, followed by (2) rhesus macaque and finally (3) Man, but nevertheless, there are not very marked differences between the three.

Flexion is the next movement to be considered at the hip joint. The two great flexors of the hip are the Psoas Major and the Iliacus Muscles. Accessory flexors of the hip are the Tensor Fasciae Latæ: the Pectineus: Adductor Longus, Adductor Brevis: the proximal part of Adductor Magnus: the Sartorius is a feeble flexor, and the Psoas minor muscle of the Orang helps flexion at the hip joint. The Rectus Femoris also assists flexion at the hip but this only when the knee is extended.

The Psoas Major muscle has a more extensive origin in rhesus macaque than it has in Man. In the former it arises from the bodies of the seven lumbar vertebrae and from a variable number of the lumbar transverse processes, whereas in Man it arises from (1) the intervertebral fibro-cartilages above each lumbar vertebra and the adjacent margins of the vertebrae - from the inferior border of the 12th thoracic to the superior border of the 5th lumbar vertebra: (2) from the four ^{arches} aponeurotic ~~axses~~ which pass over the sides of the bodies of the first four lumbar vertebrae: (3) from the transverse processes of all the lumbar vertebrae.

So, in Man only five vertebrae are involved (the first four

lumbar vertebrae, half of T.12 and half of L.5) as compared to the seven macaque vertebrae. The origin of the Orang muscle is relatively still less extensive than the origin of the human muscle, since it arises from the antero-lateral surface of only the first four lumbar vertebrae and from their transverse processes. The insertion is the same in all three primates. From this it is obvious that the rhesus monkey has a greater muscle relatively than either Man or Orang, and as such must have the most powerful flexor action on the hip joint of the three. To enhance this relative superiority the pronograde posture of the rhesus lends itself to give a greater mechanical advantage to the muscle as compared with the muscle in the orthograde posture. (The lumbar curve in Man makes up to some extent for this though). The Orang muscle is intermediate between the two extremes as far as mechanical advantage of the muscle is concerned. So the animal which possesses the relatively strongest Psoas Major muscle is the Rhesus monkey, and this superiority over Man and Orang, is marked. The latter animal possesses relatively the weakest muscle, but it is nevertheless, almost as strong as the human.

The Iliacus muscle arises from the false pelvis or iliac fossa in the macaque, Orang and Man in a similar manner in all three. However, the iliac fossae of the Macacus rhesus, and Orang, are much greater in size relatively than that of Man. The rhesus monkey has a more elongated iliac fossa than has the Orang but, on the other hand, the Orang has a much broader iliac fossa than has the macaque, being roughly speaking, about twice as broad. The human iliac fossa is relatively much broader than that of Phebus macaque, being about a third as broad again as that of rhesus monkey, but since the iliac fossa of this latter animal is relatively twice as long as the human

iliac fossa, its total surface area is greater than the human's. The Orang has definitely the greatest iliac fossa, relatively speaking, of the three, with the macaque as second while Man possesses the smallest iliac fossa. The Iliacus is thus greatest in the Orang, then in the Rhesus monkey and finally weakest and smallest in Man, even though the latter has additional origins from the ala of the sacrum, the anterior sacro-iliac, lumbo-sacral, and ilio-lumbar ligaments, and also from the capsule of the hip joint. The insertion is very similar in all three, being a little more extensive in Man, whose muscle inserts not only into the lesser trochanter with Psoas major but also into the femur for a little distance below the lesser trochanter.

Considering the two main flexors of the hip together as the Iliopsoas, it appears that the Orang combination of a very powerful Iliacus, with the relatively weakest Psoas, is about equal to, or perhaps a little less powerful than, the macaque combination of a very powerful Psoas Major muscle with a somewhat weaker Iliacus. The human condition is very definitely the weakest of all the three, the combination being that of a relatively weak Psoas Major with the weakest Iliacus muscle.

The Tensor Fasciae Latae is present in Rhesus monkey and Man but absent in the Orang. It is best developed in Man but that of Rhesus has a better mechanical advantage for flexion because of the pronograde posture and because of the elongated ilium. For flexion of the hip joint the human muscle is at a disadvantage due to the orthograde posture and the shorter ilium.

The Pectineus has already been discussed under "Adduction" and it was seen there that due to a more distal insertion the rhesus muscle attained relatively greater power over the hip joint than the human or orang muscle. The relative strength

for this muscle was (1) Rhesus macaque, (2) Man, (3) Orang.

The Adductor Longus and Adductor Brevis have already been discussed (under "Adduction"), and it was concluded that the former muscle was relatively about equal in all three, while the latter was relatively weakest in the rhesus monkey and about equal in the Orang and Man.

The proximal fibres of Adductor Magnus assist in flexion of the hip joint. As the proximal fibres are better represented in rhesus macaque due to the comparatively anterior extension of the origin of this muscle, they must have greater flexing ability over the hip joint in this animal than in Man or the Orang.

The Sartorius is a feeble flexor of the hip joint, and is about equal as a muscle in all three but, due to the pronograde posture and greatly elongated iliac wing, it has greatest mechanical advantage for flexion in the macaque. For similar reasons the Orang sartorius is superior at flexion of the hip than the Human sartorius muscle.

The Scensorius, which appears only in the Orang, assists at flexion of the hip.

The Pectus femoris acts on the hip as a flexor only when the leg is extended. Usually this occurs in Man to a very much greater extent than in Orang or the Rhesus macaque, and thus may be considered a flexor of the hip in Man alone.

Considering these muscles which assist at flexion, it is seen that the rhesus monkey is most powerful in the Pectineus, Sartorius and upper fibres of Adductor Magnus, while it is about equal to the other two animals in the Adductor Longus. Tensor Fasciae latae, Adductor Brevis and Rectus Femoris are greatest relatively in Man. The Orang has only^y the Scensorius to its credit side when compared to Rhesus and Man. Thus, summing up,

these accessory flexor muscles it appears that the Rhesus group are relatively more powerful than the Human group, which in turn is superior to the Orang group. Combining this accessory flexor group with the main flexor group, it is seen that the Rhesus macaque stands out as being the predominant member of the three at Flexion of the Hip, while the relative inferiority of the human to the Orang is decreased, and the Orang's superiority to the human group of flexors is decreased. However, as there is such a great superiority in the important main flexor group in the Orang as compared with the Human, it is hardly likely that the modifications produced by the accessory flexor group of muscles will really change the Orang's superiority very much. So the result arrived at after considering Flexion at the Hip Joint is that the macaque is the best equipped of the three for flexion, the Human has the least power of the three, relatively, for flexion, while the Orang is intermediate between Rhesus monkey and Man.

Extension of the Hip Joint is brought about mainly by the Gluteus Maximus, but it receives a great deal of assistance from the Long head of Biceps Femoris, the Semitendinosus, the Semimembranosus, and the distal fibres of Adductor Magnus. In the Rhesus monkey due to the pronograde posture, the Gluteus Medius and Gluteus Minimus come to play a major part in extension of the hip joint. The Obturator Internus and Gemelli also cause extension to a slight degree - an action not performed in the upright posture. In addition, the Hamstring muscles tend to be more dominant as flexors of the leg than as extensors of the hip in the pronograde position, just opposite to the state of affairs in the human orthograde posture.

The Gluteus Maximus is far greater in size and power in Man, relatively, than either in Rhesus monkey or Orang. The

Orang muscle is relatively stronger and more powerful than that of the macaque, but it is still not the predominant gluteal muscle, and it compares much more closely with the structure in rhesus monkey than that in Man. In the macaque the gluteus maximus arises simply from the transverse processes of the upper two or more caudal vertebrae and from the dorsal fascia over the sacrum. In the Orang the origin has extended cranially a considerable distance, being from: (1) the dorsum and tip of the Coccyx; (2) the dorsum of the Sacrum; (3) from the lower posterior portion of the iliac crest; and finally (4) from the posterior part of the dense sheet of fascia covering Gluteus Medius. The human muscle has comparatively a larger origin from the dorsum ilii than has the orang muscle. The human muscle arises (1) from the dorsum of the sacrum and coccyx (2) from the tendon of the sacrospinalis muscle; (3) from a portion of the area on the dorsum ilii above the posterior gluteal line; (4) the posterior surface of the sacro-tuberous ligament; (5) from the deep fascia ensheathing it. The orang muscle does not have the same attachments to the dorsum ilii or to the sacro-tuberous ligament as Man's muscle, but it has far greater origin from the dense fascia covering Gluteus Medius than has Man's muscle, and by this means it gains indirect attachment to a considerable part of the posterior iliac crest.

The bulk of the muscle is relatively very much greater in Man, than either in Rhesus monkey or Orang. The insertions differ somewhat in the three. In the macaque some of the fibres insert directly upon the fascia lata, the remainder converging beneath the cranial margin of the biceps femoris to insert by strong tendon bundles upon the greater trochanter of the femur and along the linea aspera for a little distance. In Man we find the muscle inserted by short tendinous fibres partly into

the fascia lata over the greater trochanter of the femur (joining the ilio-tibial tract) and partly into the gluteal tuberosity. The fascia lata receives the insertion of the whole of the superficial fibres of the muscle and the superior half of the deep fibres. The inferior half of the deep portion of the muscle is inserted for the most part into the gluteal tuberosity, but the most inferior fibres of all are inserted into the fascia lata and are thereby connected with the lateral intermuscular septum and the origin of the short head of biceps femoris. In the Orang the insertion is into the fascia lata, into the gluteal tuberosity on the shaft of the femur, and into the lateral intermuscular septum.

Comparing the rhesus and human insertions, it is seen that the insertion into the fascia lata has increased enormously in man, whereas the insertion into the gluteal tuberosity has not increased much in man as compared to rhesus monkey. A comparison between orang insertion and human insertion shows that in Man the insertion into the ilio-tibial tract has increased while that into the lateral intermuscular septum has been reduced.

The lower separated part of Gluteus Maximus, described also by Sonntag and Hepburn, inserts wholly into the lateral intermuscular septum and the ilio-tibial tract, which indicates that the insertion into and control of the ilio-tibial tract and lateral intermuscular septum is almost as great in the Orang as in Man, but the method of control differs considerably. This ischio-femoral portion of muscle is probably the homologue of the inferior fibres of the deep portion of the human muscle, which have the same insertion.

This lower ischio-condylar part resembles the upper portion of the biceps femoris in the Rhesus macaque. The lower fibres

of Gluteus Maximus are more specialized for adduction and lateral rotation than for extension of the hip. The upper fibres are more specialized for extension of the hip. Since the Orang has the lower fibres greatly developed in the form of the ischio-femoral portion of the muscle, it seems obvious that Adduction and lateral rotation are preferred to extension. Man, on the other hand, due to his greatly developed upper and superficial fibres equally obviously prefers extension of the hip joint. The relative strengths of the Gluteus Maximus for extension of the hip are in the order: (1) Man, (2) Orang, (3) Rhesus macaque.

In the Rhesus monkey, and probably also in the Orang, the Gluteus Medius and Gluteus Minimus function as major extensors of the hip. The Obturator Internus, assisted by the Gemelli, also extends the hip joint to some slight degree when the thigh is flexed. These extensor forces are completely lacking in the normal orthograde posture of Man.

The Hamstring muscles function best as extensors of the hip when the leg is extended at the knee joint - indicating that they should be best adapted for this function in Man. However, the macaque and Orang have certain mechanisms by which this difficulty may be overcome. Thus, the long head of Biceps Femoris has a very similar origin in all three primates. The insertions differ somewhat in form, that of the Rhesus monkey being very wide and diffuse, that of Orang being less wide, while Man's insertion is the most narrow and specific. Taking the mid-point of the insertion in each, it is seen that this point is almost in the same position in each case, being at the head of the fibula. The extension of the insertion on to the lower end of the thigh (fascia lata and femur) in Rhesus monkey and Orang causes this portion of muscle to have greater force at extension of the hip than the human muscle. It gains this added force, however, only

by sacrificing its power below the knee joint. Thus, by the insertion alone the Ihesus muscle and Orang muscle have relatively greater power for extending the hip joint than has the human muscle.

The flexed thigh of the pronograde posture lends greater power for extension of the hip joint by the hamstrings than is the case in the upright posture. In the former the line of leverage between the origin of the muscles (from the ischial tuberosity) and the hip joint is nearly at a right angle with the shaft of the femur, while in the latter posture the amount of leverage is lessened due to the ischial tuberosity being approximated more closely to the shaft of the femur thus reducing the angle to an acute angle.

The distance between the ischial tuberosity and the acetabulum is relatively greatest in the Orang, then in the Ihesus macaque, and finally is shortest in Man. The leverage which the hamstrings exert via their origin is thus correspondingly greatest in the Orang, less in the macaque, and least in Man.

The origins of Semimembranosus and Semi-tendinosus are similar in the Ihesus monkey, in the Orang and in Man. The mid-points of their respective insertions are approximately the same in all three, so that their function of extension is determined mainly by the physical factors mentioned above.

The Ihesus monkey possesses the Semimembranosus Accessorius muscle which attaches from the ischial tuberosity to the lower part of the shaft of the femur. This would assist in extension of the hip in the macaque. In the human this muscle has been incorporated into the Adductor Magnus muscle.

The remaining muscle which assists at extension of the hip is the lower portion of Adductor Magnus. The Orang and Man both possess this ischio-condylar portion of the muscle, but it is

absent in the Rhesus macaque. The latter, however, compensates to some extent for this lack by possessing the semimembranosus accessorius muscle. The Orang is relatively most powerful in this portion of muscle due to the advantages of a semi-pronograde posture and having the greater distance between the origin of the muscle and the acetabulum.

Reviewing the extensors of the hip, it is apparent that even though the Gluteus Maximus is definitely most powerful in Man, it cannot be greater than the extensor mechanism existing in Orang and Rhesus macaque where all three gluteal muscles are major extensors of the hip. The latter two animals also possess a weak extensor of the hip in the form of the Obturator Internus and Gemelli which the human lacks. The Hamstring muscles have apparently been adapted more successfully for extension in Orang and Rhesus monkey than they have in Man. Finally, the ischio-condylar portion of Adductor Magnus seems to be relatively most powerful of the three in the Orang.

Altogether, therefore, it seems that Orang and Rhesus monkey have a more adequate extensor mechanism for the hip joint than Man, and of the former two, Orang appears to be the stronger. It is of importance to note, however, that the human thigh generally moves from a position of partial flexion to one of full extension, while in the Rhesus monkey and Orang the movement is usually from complete flexion to one of partial extension of the hip joint.

MEDIAL ROTATION: at the hip joint is brought about by no one muscle in particular, but by a number of muscles which have medial rotation as a secondary action. In the orthograde posture these muscles are the Tensor Fasciae Latae, the Gluteus Medius, Anterior fibres of Gluteus Minimus, the Ilio-psoas and the distal fibres of Adductor Magnus. In the pronograde position,

when the hip joint is flexed, the Gluteus Medius and Gluteus Minimus do not appear to function as medial rotators. The Ilio-psoas likewise, instead of functioning as a weak medial rotator now functions as a weak lateral rotator of the thigh.

As discussed under "Abduction" the Tensor Fasciae Latae is lacking in the Orang, but present in the Phebus macaque and Man, being much better developed in the latter. The Gluteus Medius and Gluteus Minimus muscles may be considered to act as medial rotators only in Man, and likewise the Ilio-psoas appears as a medial rotator only in the human. The Scansorius, an almost exclusively Orang muscle, assists considerably in internal rotation.

The distal fibres of Adductor Magnus are equally well developed in Orang and Man, but are not present as such in Phebus monkey. Instead, in this latter primate, the Semi-membranosus Accessorius takes over this function, but it probably is weaker compared to the action produced in Orang and Man.

Thus, it is apparent that Man is unquestionably the most powerful of the three primates at Medial Rotation of the hip with the Phebus macaque the weakest of all, being weaker than Orang due to the lack of a Scansorius muscle and also the lower fibres of Adductor Magnus.

The muscles producing Lateral Rotation at the Hip Joint are numerous. The main lateral rotators are the Piriformis, and the Obturator Internus with its Gemelli, the Quadratus femoris, and the Obturator Externus. Assisting lateral rotators are the lower fibres of Gluteus Maximus, the posterior fibres of Gluteus Minimus when the thigh is extended, the Adductor Longus, the Adductor Brevis, the proximal part of Adductor Magnus and the Sartorius. In the pronograde position Ilio-psoas assists lateral rotation.

The origin of the Piriformis is greater in extent in Man as compared to the origin in Rhesus monkey, since in the latter animal the muscle arises solely from the transverse processes of the last two sacral vertebrae, while in Man it arises from the roots of the vertebral arches of the second, third and fourth sacral vertebrae, from the adjacent part of the bone lateral to the anterior sacral foramina, from the upper margin of the greater sciatic notch of the ilium, and finally, from the pelvic surface of the sacro-tuberous ligament. Thus in Man, as compared to rhesus, the sacral origin has been extended, and there is additional attachment to the iliac bone and sacro-tuberous ligament. The insertions are about equal in both. The orang origin is less extensive than Man's, being from the anterior surface of the sacrum extending from between the lower edge of the sacro-iliac junction and the sacro-spinous ligament. It has no attachment to the border of the Greater Sciatic Notch or to the Sacro-tuberous ligament as has man's muscle. Insertion is similar to that of Man and rhesus macaque. Thus the muscle is best developed and relatively most powerful in Man, being about equal relatively in Orang and the macaque. The Piriformis, like the Obturator Internus, acts as a lateral rotator only when the thigh is extended - a position obtaining in Man rather than in Orang or Rhesus monkey. So this confirms Man's piriformis as being the most powerful of the three.

The Obturator Internus has relatively greater origin in Man than in the rhesus monkey or Orang. In the human the origin has spread well up above the level of the ilio-pubic junction, coming to occupy the greater part of the Sacro-pelvic surface of the ilium right up to the lower edge of the auricular surface of the ilium. In Man there appears to be some reduction in the attachment to the pubic bone as compared with the rhesus, since the

pubic ramus and upper half of the symphysis pubis is free of the origin of this muscle. Insertion is similar in all three primates. The Gemelli are present in rhesus monkey, Orang and Man, those of Orang differing slightly in that the Superior Gemellus is weak and the Inferior Gemellus is very strong, while in the macaque they are as a continuous sheet of muscle. Man's muscle is relatively the most extensive and most powerful of the three. The upright posture in the human further enhances the value and power of the muscle as a lateral rotator of the thigh. The other muscles concerned with Lateral Rotation have already been discussed previously under the other movements of the hip joint. Under "Adduction" it was seen that the quadratus femoris had about equal power in rhesus macaque, Orang and Man, relatively speaking. The greater relative distance between the acetabulum and origin of quadratus femoris in the rhesus monkey and orang as compared to Man, together with the pronograde posture in the macaque, gives the rhesus muscle greater leverage at the joint and, therefore, greater mechanical advantage for lateral rotation than is the case in Man. The Orang is intermediate between the two.

The Obturator Externus, as described under "Adduction" is a better lateral rotator of the hip in the rhesus monkey than it is in Orang or Man, these last two having this muscle equal in power.

Summing up these main lateral rotators of the hip it seems that the superiority of Man in his piriformis, and obturator internus and gemelli, is greatly counterbalanced by the relative superiority of rhesus with its quadratus femoris and obturator externus muscles. Of the two, the former group (piriformis, obturator internus and gemelli) is probably more powerful than the latter group (quadratus femoris and obturator externus), so that Man still maintains the relative superiority for Lateral Rotation, but only by a comparatively small margin. The Orang

and Rhesus monkey are relatively equal.

Considering the accessory group of lateral rotators it is seen that the lower fibres of Gluteus Maximus are best developed in the Orang (see under "Extension") and about equally developed in the macaque and Man. So here the Orang has definitely more power at lateral rotation than either Man or Rhesus monkey. The Gluteus Minimus, as such, is strongest in Man, but as only the posterior fibres are concerned, the actual muscle power is relatively equal in all three animals. However, Man's upright posture causes the origin of these posterior fibres to be further posterior in relation to the hip joint than is the case in the macaque with his pronograde posture or in the Orang. The result is that Man has greater mechanical advantage for lateral rotation than either rhesus monkey or orang.

The Adductor Longus muscle has relatively equal origin in the Rhesus macaque, Orang and Man. However, the insertions differ somewhat, that in the macaque being into a considerable portion of the upper part of the linea aspera, in man into the middle two-fourths of the linea aspera, and in orang into the third quarter of the linea aspera. Now, it is evident that the more distal the insertion is on the femur the better it is for adduction - but the reverse holds for lateral rotation. The nearer the insertion is to the level of the hip joint the greater will be the power of lateral rotation. So then the rhesus muscle, though relatively weakest at adduction is relatively strongest at lateral rotation, with the human muscle second and Orang muscle weakest.

The Adductor Brevis has been described and compared under "Adduction". It was seen that there was not a very great difference relatively in the origins, but there was a difference in their insertions, man's insertion being nearest the hip joint,

followed by rhesus, and orang's insertion being furthest away from the joint. It follows thus that the human condition is best of the three for lateral rotation, even though it is relatively weakest for adduction. So for Lateral rotation the order must be - (1) Man, (2) Rhesus macaque, (3) Orang.

The proximal fibres of Adductor Magnus are about equal in all three, and even though the human insertion extends a little higher on the femur than the insertion in the macaque, the lateral rotating power must be about equal relatively in the rhesus monkey, Orang and Man.

The Sartorius as a muscle is about equal in all three, but the pronograde posture and the relatively greater cranial projection of the ilium in the rhesus monkey causes the muscle in this animal to have a greater mechanical advantage at lateral rotation than exists in the orthograde human. The Orang is intermediate. The actual power of the sartorius as a lateral rotator cannot, however, be great.

Summing up the accessory lateral rotators it is apparent that Man is most powerful in the posterior fibres of Gluteus Minimus and in the Adductor Brevis, while the rhesus monkey is most powerful in Adductor Longus and Sartorius, Orang being most powerful in the lower fibres of Gluteus Maximus. This last is the most powerful accessory factor for lateral rotation of all. Man's relative superiority over the Orang with the posterior fibres of Gluteus Minimus, the Adductor Longus and the Adductor Brevis, possibly makes up for this great advantage in the Orang. The relatively greater power for Lateral rotation of the Orang's Sartorius over the human's muscle may place the Orang just about equal to the human. The rhesus macaque is superior to the Orang in the Adductor Longus, Adductor Brevis and Sartorius muscles. This should balance the superiority of the lower fibres of Gluteus

Maximus in the Orang. In Rhesus and in Orang the ilio-psoas assists in lateral rotation. Thus, in all, there does not appear to be any great difference between the three animals. Combining this with the results obtained from a comparison of the main lateral rotators, the final results is that Man is the most superior of the three at Lateral rotation, while the Rhesus monkey and Orang about equal each other - i.e., (1) Man, (2) Orang and Rhesus macaque. Nevertheless, Man's relative superiority is not very marked.

Reviewing now the results obtained with each movement at the hip joint, it is seen that the order of relative superiority was as follows:-

<u>ADDUCTION:</u>	(1) Orang	(2) Man	(3) Rhesus macaque
<u>ABDUCTION:</u>	(1) Orang	(2) Rhesus macaque	(3) Man
<u>FLEXION:</u>	(1) Rhesus macaque	(2) Orang	(3) Man
<u>EXTENSION:</u>	(1) Orang	(2) Rhesus macaque	(3) Man
<u>MEDIAL ROTATION:</u>	(1) Man	(2) Orang	(3) Rhesus macaque
<u>LATERAL ROTATION:</u>	(1) Man	(2) Orang & Rhesus macaque	(3) -

Thus, from this it is apparent that the Rhesus monkey is relatively the strongest of the three at flexion of the hip joint, the Orang at Adduction, Abduction and Extension of the hip joint, and Man Medial and Lateral Rotation of the hip joint.

Rhesus monkey is greatest at Flexion - a most important movement in the pronograde position in which progression is made by the forwards and backwards movement of the lower limbs on the trunk, and flexion is far more important than extension since the

thigh is usually maintained in various degrees of flexion in the pronograde posture. Extension is not so important because the lower limbs themselves are not used as individual organs for climbing, as in the Orang, but simply for pronograde progression. This animal often progresses by springing from branch to branch - the force here being derived from flexing the spine, the hips and lower limbs, and then suddenly extending them as a whole.

Orang has Extension as one of its greatest movements at the hip - and this is what one would expect since this is the essential movement in climbing, and the orang does a great deal of climbing in his arboreal haunts - far more than either of the other two animals concerned. Abduction and Adduction also fit the picture because the Orang uses his lower limbs, not as structures on which to balance his body as in Man, or to share with the fore-limbs the weight of the body as in the pronograde posture in rhesus monkey, but as individual grasping organs with which to transport his body among the branches of trees. Man must balance his body on his lower limbs otherwise the upright posture is impossible. Flexion, extension, abduction and adduction are all important, but not one more than the other, for if this were so, the balance required here would be prejudiced by a dominant force in one direction. Medial and Lateral rotation, movements not especially required by the pronograde rhesus monkey or by the climbing Orang, become important in the upright posture of Man, to maintain that fine control needed for balance when man transposes his weight from one limb to the other as in walking, and when he rotates his body to one side or other, as, for example, when turning to look backwards over his shoulder. Thus the results obtained from a consideration of the hip joint musculature all fit into a logical picture.

KNEE JOINT:

The next joint, the knee joint has four movements in all, two major and two minor. The major movements are those of Flexion and Extension, the minor movements are Medial Rotation and Lateral Rotation.

The muscles causing Flexion at the knee are chiefly the hamstrings (Biceps femoris, Semitendinosus and Semimembranosus); but these are assisted by the Popliteus, Plantaris, Gastrocnemius, Gracilis and Sartorius muscles.

The long head of Biceps Femoris has a relatively similar origin from the ischial tuberosity in the Rhesus macaque, Orang and Man, and though there are some slight variations of origin these are not of great practical importance. However, there exists a considerable difference in the insertion of this muscle. In the Rhesus monkey the anterior fibres attach extensively into the fascia lata, while the remainder of the muscle disappears into an aponeurosis which attaches over the anterior border of the leg. The exceedingly broad crural insertion extends for about half the distance to the ankle. The insertion in the Orang is into the lateral surface of the distal half of the shaft of the femur by means of a tough fibrous membrane (which fuses with the lateral intermuscular septum) and then continues distally along the lateral edge of the Vastus Lateralis tendon, into the antero-lateral surface of the head of the tibia and into the lateral surface of the head of the fibula, and finally into the deep fascia over the lateral portion of the leg. In Man the long head of Biceps Femoris does not enjoy a separate insertion but fuses with that of the short head of the muscle. The common insertion is into the head of the fibula by a strong round tendon, into the lateral condyle of the tibia by a slip, and finally by a distal expansion into the deep fascia on the lateral side of

the leg. In the human, therefore, the insertion has moved distally off the lower portion of the thigh, and has concentrated itself below the knee, mostly into the head of the fibula.

Similarly the insertion does not extend so far down the leg as does the Rhesus macaque insertion or the Orang insertion, but has become limited to the area just below the head of the fibula.

This more specific insertion in Man is more appropriate to the upright posture, while the extensive insertion found in the macaque and Orang favour a posture in which the knee and hip joints are usually kept flexed.

The strength of the muscle for flexing the knee joint must be relatively strongest in Man since the whole muscle force is concentrated below the knee joint, while in the Rhesus monkey and Orang only about half the muscle force acts below the knee joint, the other half acting above the knee. This arrangement in the Orang and Rhesus monkey is much more favourable for extension of the hip joint - as in climbing - but this advantage is gained only by sacrificing power below the knee joint.

The pronograde posture in which the knee joint is flexed to approximately a right angle, is mechanically advantageous to the hamstrings for flexion at the knee, as compared to the orthograde position in which the knee joint is extended to an angle of about 180°. In the pronograde position the origin - (the ischial tuberosity) - is moved further away from the knee joint, whereas in the orthograde position the ischial tuberosity is moved nearer the knee joint. But the relative distance remains approximately the same in orthograde and pronograde postures, for the reduced distance between the knee and the ischial tuberosity in the orthograde posture is made good by the extension of the knee joint, while the greater distance of the ischial tuberosity from the knee joint in the pronograde posture is reduced by the flexion of

the leg.

Thus the superiority of the human due to greater muscle force is offset by the mechanical advantage found in the Rhesus monkey and Orang. If, of course, the human were to place himself in the pronograde posture he would be very definitely superior to the Orang and Rhesus monkey as far as the flexor action of the Long Head of Biceps is concerned, for he would have both mechanical advantage plus greater muscle force.

The short head of Biceps Femoris is absent in the Rhesus macaque. In the Orang the Short head is an entirely separate muscle, having no connections or fusions with the long head. It is divided into two distinct bellies which are separable from one another in their whole extent, - (in my Orang, at least). The smaller head is superficial to the posterior portion of the larger head. It arises by a long thin tendon from the lateral surface of the shaft of the femur below the greater trochanter, just proximal to the bony insertion of Gluteus Maximus. About half way down the thigh the muscle belly commences. It inserts partly with the tendon of the deeper portion of the short head of biceps, but by far the greater portion of its insertion is into the very dense deep fascia over the lateral surface of the leg. The larger deep belly arises by fleshy fibres from the distal two-thirds of the postero-lateral aspect of the shaft of the femur, just posterior to the attachment of the lateral inter-muscular septum. This portion inserts into the lateral surface of the head of the fibula and into the deep fascia over the lateral and anterior surfaces of the leg. In Man the short head of Biceps arises from (1) the whole length of the lateral lip of the linea aspera and the proximal two-thirds of the lateral epicondylar line of the femur, and (2) the lateral intermuscular septum. The proximal limit of its origin is sometimes blended

with the insertion of the lowest fibres of the Gluteus Maximus.

This short head has thus a more extensive origin in the Orang due to the smaller superficial head of this muscle which arises between the Gluteal tuberosity and the greater trochanter of the femur. This portion is entirely lacking in Man. The larger head in the Orang corresponds fairly closely with the short head in Man, at least, as far as its origin is concerned, the main difference here being that the lateral intermuscular septum does not supply much origin to the Orang muscle. In this animal the muscle remains entirely separate, in Man it fuses with the long head of Biceps. The insertion in the Orang is more diffuse than in the human and extends further down the leg.

Due to the lower insertion in Orang and also the greater mechanical advantage obtained by a usually somewhat flexed knee joint, the Orang probably has a relatively greater power at flexing the knee joint with the short head of Biceps than has Man with his muscle. The human insertion is more secure as it is mainly into bone (head of fibula) while the Orang insertion is mainly into deep fascia.

Reviewing the Biceps Femoris as a whole, the superiority gained by the Human over the Orang with the long head is counter-balanced by the Orang's superiority with the short head. The Rhesus macaque is relatively far behind either of these others due mainly to the absence of the short head. The relative positions for the flexing action on the knee joint of the Biceps femoris are (1) Orang and Man about equal and (2) Rhesus macaque definitely much weaker.

The Semitendinosus has a very similar origin in Rhesus macaque, Orang and Man. The only differences exist in the insertions. The site of insertion is similar in Man and Rhesus monkey, one difference being that the tendon of insertion in the

macaque is broader, relatively, than the tendon of insertion in Man. The insertion in the Orang is more bulky and more extensive than that either in Man or Rhesus monkey. This alone places the Orang muscle at an advantage for flexion at the knee. As described above, the pronograde posture is mechanically advantageous for flexion of the knee by the hamstrings, whereas the orthograde posture does not lend itself so well to such action by the hamstrings. The positions of relative greatness at flexing the knee as far as the Semitendinosus is concerned, are -

(1) Orang (due to broadness of insertion and partly pronograde posture of lower limbs); (2) Rhesus macaque (due to pronograde posture and also having relatively broader insertion than Man) and (3) Man.

The Semimembranosus muscle has a very similar origin in all three subjects. The macaque has a semimembranosus accessorius muscle which, however, has no action over the knee joint. In Man the semimembranosus accessorius has been incorporated in the Adductor Magnus. The Semimembranosus proprius of Rhesus corresponds to the muscle in Orang and Man. Insertion is similar in all three primates, the only difference being a posterior displacement, together with secondary or additional insertions in Man due, no doubt, to his upright posture. In Rhesus monkey the insertion is into the medial surface of the tibial tuberosity and into the capsule of the knee joint. The Orang insertion is into the medial surface of the head of the tibia, into the adjacent deep fascia, into the Posterior Oblique Ligament of the Knee Joint, and slightly into the fascia over the popliteus muscle. The human insertion is into the horizontal groove on the postero-medial aspect of the medial condyle of the tibia. It has additional membranous^a insertions into the posterior border of the tibial collateral ligament of the knee joint, into the fascia

covering the popliteus muscle, attaching to the oblique line of the tibia, and finally a strong band extends proximally and laterally to the back of the lateral condyle of the femur, forming the oblique popliteal ligament of the knee joint. As a result of the posterior displacement of the insertion the human muscle cannot be such a strong medial rotator of the leg as it is in Orang and Rhesus macaque.

Summing up the major flexors of the knee, it seems that the advantages the rhesus monkey obtains from the Semitendinosus and Semimembranosus as compared to these muscles in Man, is counterbalanced by Man's advantages over the macaque with the Long head of Biceps and also with the Short head of Biceps. Thus Man and Rhesus monkey must be about equal to each other. The Orang is relatively more powerful than Man with the Semimembranosus and Semitendinosus, (being also more powerful than the rhesus with the latter muscle) and it is also most powerful of all with Short head of Biceps. The Orang thus has the most powerful group of hamstrings of the three, rhesus monkey and Man being about equal to one another.

The Popliteus muscle is so similar in origin, form and insertion in the Rhesus monkey, Orang and Man, that there cannot be much difference relatively in the power of flexing the knee joint between the three.

The Plantaris muscle is absent in the Orang, but present in Rhesus monkey and Man. It is a very small and insignificant muscle in Man, but it is a muscle of considerable bulk in the macaque. Thus it follows that even though this muscle does not exert a great influence in flexing the knee joint, it is nevertheless relatively strongest in Rhesus monkey, weaker in Man, and cannot be taken into account at all in the Orang.

The Gastrocnemius is very similar in the Rhesus monkey, in

the Orang and in Man, and probably exerts about an equal force for flexion of the knee joint in all three. There is some evidence, however, that in Man the origins are relatively more proximal on the femur than in Rhesus monkey or Orang, this being a compensating mechanism for the extended knee.

The Gracilis muscle has by far the greatest origin in the Orang, being a little greater in Man than in the macaque. The bulk of the muscle is also much greater, relatively, in Orang than in Man or Rhesus monkey. Further, the insertion is more extensive and more distal on the tibia in the Orang than it is either in Man or in Rhesus monkey. The usually slightly flexed attitude of the knee in the Orang also enhances the power of this muscle for flexion of the knee. Thus, the Orang muscle is by far the strongest of the three for flexion at the knee joint. The human muscle is relatively more bulky than that of the macaque, but the macaque's pronograde posture gives its muscle a mechanical advantage for flexion, so the result is that Man and Rhesus monkey are probably about equal.

The Sartorius, though a weak flexor of the knee joint, and though about equal as a muscle in Rhesus macaque, Orang and Man, is nevertheless, at a better mechanical advantage for flexion in the pronograde posture than in the orthograde posture. Thus Orang and Rhesus monkey may be considered about equal with Man weakest.

Reviewing the accessory flexors of the knee, it is seen that the Popliteus and Gastrocnemius are relatively equal in all three, so they can be discarded from further discussion on comparisons. The Plantaris and Sartorius muscles are relatively greater for flexion of the knee, in Rhesus monkey than in Man. The Orang is relatively greatest of all three in the Gracilis and greater than Man in the Sartorius. Thus Man seems definitely the weakest of

the three. It remains now to see which is the stronger between the macaque and Orang. The Sartorius has been considered about equal in both, so the difference depends on a comparison between the relative strengths for flexion of the knee joint of the Plantaris (which is well developed in Rhesus monkey but absent in Orang) and of the Gracilis (which is very well developed in Orang). Owing to the position of origin and insertion in relation to the knee the Gracilis has greater mechanical advantage for flexing the knee joint than has the Plantaris. So the relative strengths of the accessory flexor muscles at the knee are (1) Orang, (2) Rhesus macaque, (3) Man.

Combining these results with those obtained from a consideration of the main flexors of the knee, it is apparent that the Orang's superiority is confirmed, while the Rhesus macaque advances a little ahead of Man - (merely because of Plantaris and Sartorius - two very feeble flexors of the knee).

Extension of the knee joint is brought about by the Quadriceps Femoris. Assisting extension (in Man) are the Gluteus Maximus and Tensor Fasciae Latae. The Rectus Femoris apparently differs in Rhesus monkey and Man mainly in the origin of the muscle. In the macaque the origin is by a single head from the small rectus femoris (ante-acetabular) process which is situated a short distance cranial to the acetabulum along the acetabular border of the ilium. This probably corresponds mainly to the straight head of origin of Man's muscle. The human muscle arises by two heads: the straight head from the anterior inferior spine of the ilium; the reflected head from a rough groove on the dorsum illi just above the highest part of the acetabulum. The Orang muscle arises by only one tendon, but it incorporates two as they are in Man - it is as if the two heads were fused into

one sheet. The remainder of the muscle is very similar in all three. Thus, because of the somewhat weaker origin the rhesus muscle is probably a little less powerful than either the muscle in Man or in Orang.

The origin of the Vastus Lateralis is much more extensive in Man than it is in Rhesus macaque. In the latter animal the muscle arises from the entire lateral aspect of the greater trochanter of the femur. In Man the muscle arises from (1) the capsule of the hip joint, (2) the tubercle of the femur, (3) a concave area on the anterior surface of the shaft of the bone medial to the greater trochanter, (4) the distal border of the greater trochanter, (5) the lateral margin of the gluteal tuberosity of the femur and the tendon of the Gluteus Maximus, (6) the proximal half of the linea aspera, and (7) the fascia lata and lateral intermuscular septum.

Thus in Man as compared to rhesus monkey, therefore, the origin of the muscle has moved from the lateral surface of the greater trochanter, limiting itself here only to the distal border of the greater trochanter. However, it has spread medially, and extensively downwards along the femur. The Orang muscle has an origin resembling fairly closely that of Man. The muscle itself, however, is more intimately fused with the Vastus Intermedius than is the case in Man.

The chief difference between the Vastus Medialis in the Rhesus macaque and in Man is that in the former animal the muscle has not such an extensive origin as in Man. The origin of Man's muscle not only extends slightly further up the femur than the origin of Rhesus' muscle, but it also extends to a very great extent further downwards along the femur than the rhesus muscle. In addition Man's muscle gains considerable origin from the medial intermuscular septum and tendon of Adductor Magnus -

attachments apparently lacking in the Rhesus monkey. The Orang muscle corresponds very closely with the human muscle, except that there is no attachment to the tendon of Adductor Magnus, and that in Man the muscle apparently does not give much insertion into the deep fascia of the leg. Also, in my Orang, this muscle did not seem to be so much fused with the Vastus Intermedius as it is in Man.

The Vastus Intermedius muscle differs in origin in all three. In the monkey it arises from the entire anterior aspect of the distal three-quarters of the shaft of the femur. In Man the origin is more extensive, coming from the proximal two-thirds of the shaft of the femur on the anterior and lateral surfaces, from the distal half of the lateral lip of the linea aspera and the proximal part of the lateral supracondylar line, and finally from the lateral intermuscular septum. The Orang's origin, as I found it, is more extensive than in Man, being from the proximal three-quarters of the shaft of the femur on its lateral, anterior and medial surfaces.

Thus, taking the Quadriceps Femoris as a whole, it is seen that the human portions of this muscle mass consistently have much more extensive origins than do those of the Rhesus monkey. Also the parts of the muscle mass are more differentiated and separate from one another in Man than they are in the monkey. The Orang's quadriceps resembles that of Man more closely than that of Rhesus monkey. It is not so clearly differentiated into parts as in the human, but the extent of the origin is very similar in both. The quadriceps tends to have stronger attachment on the medial side of the thigh in the Orang (due to the origin of Vastus Intermedius from this surface of the femur and to the Vastus Medialis tending to fuse greatly with the Vastus Intermedius), while in Man it tends to have a stronger at-

ment on the lateral side of the thigh (since Man's Vastus Intermedius has attachment to lateral lip of linea aspera, to lateral intermuscular septum, and the Vastus Lateralis tends to fuse with the Vastus Intermedius). Might this arrangement be due to the Orang's thigh usually being somewhat abducted and laterally rotated, while Man's thigh is usually adducted and held midway between lateral and medial rotation?

As far as extension at the knee by the quadriceps is concerned, Orang and Man are probably almost equal, while the Rhesus macaque is weaker than these two.

The Gluteus Maximus and Tensor Fasciae Latae acting through the ilio-tibial tract assist in maintaining the leg in extension. This mechanism must come into play much more frequently in Man than either in Orang or the Rhesus macaque, because in the upright posture of Man the leg is usually extended, while in the pronograde posture of the macaque and semi-pronograde posture of the Orang, the leg is usually flexed. Besides this the human Gluteus maximus is much greater in size and much more powerful than either that in the Rhesus monkey or the Orang, and the human Tensor Fasciae Latae is more powerful than that of the Rhesus macaque, while the muscle is absent in Orang. As a result, it can be confidently said that the human is best equipped for Extension at the knee joint, next Orang and finally Rhesus monkey.

Medial Rotation of the knee joint is brought about by the Semitendinosus, by the Semimembranosus, Gracilis, Sartorius and Popliteus muscles. These have all been described above. The insertion of the Semitendinosus is broadest in Orang, next in the macaque and finally narrowest in Man; otherwise the muscles are very similar. Man's insertion being narrowest and nearest the actual joint would then have relatively the greatest medial rotating force, for the further away from the knee joint the

insertion is the less is its medial rotating power. The Semimembranosus in Man is relatively the weakest medial rotator of the three due to the posterior displacement of the insertion of the muscle in him. The Gracilis is by far the most powerful muscle in Orang. It is about equal in Man and Phebus monkey. The Sartorius and Popliteus are relatively equal in all three. The Gracilis and Semimembranosus rather causes the Orang to possess the relatively greatest medial rotating force of the three. Man and Phebus monkey are about equal (But for medial rotation the knee joint must be flexed, so this movement would come in far more useful and is probably used very much more in the Orang and Phebus macaque than in Man.)

Lateral rotation is brought about by the Biceps Femoris. Since this muscle inserts more specifically into the head of the fibula in Man than it does in Orang, the muscle must have greater lateral rotating power in Man. The Phebus muscle is very definitely the weakest of all three primates because it does not insert at all specifically into the head of the fibula and, in addition, it also lacks the short head of the muscle. However, as with Medial rotation, this movement cannot be performed when the leg is extended, as it usually is in Man's orthograde posture, but is best performed when the leg is flexed to about a right angle, - as is found in Orang and Phebus monkey.

Thus, reviewing the results obtained from an investigation of each movement of the knee joint, it is seen that the position is as follows:-

<u>Flexion:</u>	(1) Orang	(2) Phebus and Man	
		Macaque	
<u>Extension:</u>	(1) Man	(2) Orang	(3) Phebus Macaque
<u>Medial rotation:</u>	(1) Orang	(2) Phebus Macaque and Man	
<u>Lateral rotation:</u>	(1) Man	(2) Orang	(3) Phebus macaque

Man is relatively most powerful of the three at Extension of the knee joint - and, if he flexes his knee - Lateral Rotation of the joint.

The Orang is relatively most powerful in Flexion and Medial Rotation of the knee joint.

The Rhesus macaque is relatively weakest in Extension (and Lateral Rotation of the knee).

Orang is strongest at Flexion of the knee joint. This is not surprising since the lower limb is used as a prehensile organ for climbing, and so, of all the movements of the knee flexion would be the most useful to this animal. It might be thought that since the rhesus is also an arboreal denizen he must do as much, if not more climbing than the Orang. But the actual mode of climbing must be examined first. Rhesus macaque is active and jumps a great deal, using usually both his lower limbs together, while the Orang is much slower and more ponderous, and progresses by using each lower limb as an individual grasping organ, placing one above the other as he climbs. Therefore, each limb plays a much more important role in the climbing of Orang than in the climbing of Rhesus monkey. Thus, as the Orang does a great deal more actual climbing than Rhesus or man, one must expect to find a flexor mechanism which is better developed in him than in the other two. As the Orang climbs his hip is flexed, abducted and slightly laterally rotated, his knee is flexed to some extent, and his foot is inverted and is grasping the object up which he is climbing. With this picture in mind, it is obvious that a strong muscular mechanism controlling medial rotation would be much more useful than one controlling lateral rotation. As the above results show, this was found to be the case.

Comparing Man's needs at the knee joint with those of

arboreal animals, it is obvious that extension is more important to Man than to the latter animals. The maintenance of the upright posture in standing and walking requires an extended knee and so one would expect to find under such circumstances an extending mechanism superior to the extending mechanism found in Orang or Rhesus monkey and this is what is found - as the above results show.

The rhesus monkey has flexion and Medial Rotation as its two relatively strongest movements at the knee, and as these are the two most useful for an arboreal existence, these findings are not surprising. As this animal does not do as much climbing as Orang it is to be expected that these mechanisms are not so well developed as in the Orang.

THE ANKLE:

There are four possible movements at the Ankle:

Dorsi-Flexion,
Plantar-Flexion,
Inversion and
Eversion.

The latter two movements, though they do not actually take place in the ankle joint, may be conveniently included in this section.

The muscles which cause Dorsi-Flexion are the Tibialis Anterior, the Extensor Digitorum Longus, the peroneus tertius, and the Extensor Hallucis Longus.

The Tibialis Anterior is very similar in rhesus monkey, Orang and Man, and this muscle has probably relatively the same power in each. The Extensor Digitorum Longus is very similar in origin and insertion and thus also probably in power, relatively, in the macaque, Orang and Man. The Peroneus Tertius is essentially a human muscle - being absent in Orang and rhesus monkey. Its function is dorsi-flexion of the foot and also

raising up the lateral border of the foot. The Orang and Rhesus monkey are very similar in the extent of origin of the Extensor Hallucis Longus, being from the middle third of the medial surface of the fibula and from the adjacent interosseus membrane. In Man the origin of this muscle is almost twice the extent that it is in the other two primates, being from the middle two-fifths of the medial surface of the fibula and from the adjacent interosseus membrane. It follows that the bulk and thus the power of this muscle must be very much greater in Man than it is in Orang or Rhesus. This superiority, together with that obtained by the Peroneus Tertius, make Man relatively strongest of the three animals at Dorsi-Flexion of the ankle joint - since in the other two muscles concerned, the Tibialis Anterior and Extensor Digitorum Longus, are relatively equal in all three. Orang and Rhesus monkey are relatively equal to one another at dorsi-flexion of the ankle.

Plantar Flexion of the ankle is brought about by the main flexors: Gastrocnemius and Soleus; but these are assisted by the Plantaris, Flexor Digitorum Longus; Flexor Hallucis Longus, Tibialis Posterior, Peroneus Longus, and Peroneus Brevis muscles.

The Gastrocnemius muscle appears to be relatively equal in the macaque, Orang and Man, the ^{origins} ~~origins~~ and insertions comparing closely, the degree of fusion between the two bellies in the three animals being the only variation.

The Soleus is very much greater in Man than either in Orang or the Rhesus macaque. In Rhesus monkey this muscle arises by a tendon from the posterior aspect of the head of the fibula and from the neighbouring surface of the capsule of the knee joint. The origin of the Orang muscle is almost identical with this. Both give rise to a small muscle belly which terminates in a thin flat tendon. This tendon inserts with the tendon of the

medial part of the gastrocnemius tendon to form the Tendo Achilles. In Man, however, this is a large bulky muscle, which gains origin from the posterior surface of the head and proximal third of the shaft of the fibula, from a fibrous arch stretching over the popliteal vessels and tibial nerve between tibia and fibula, and from the oblique line and middle third of the medial border of the tibia. The human Soleus is, therefore, very greatly superior to either the Soleus of the Orang or Rhesus monkey, these latter two animals having their corresponding muscles about equal.

The Plantaris muscle is absent in the Orang. In Rhesus macaque this muscle has very much the same origin as it has in Man, but the actual muscle belly is relatively much greater in Rhesus monkey than it is in Man, so that the macaque must have greater flexor power due to this muscle than Man can have from his plantaris.

The Flexor Digitorum Longus appears to have very similar origin in the Rhesus macaque, Orang and Man, and appears to be very similar in bulk. The insertions differ considerably, but these differences have not a great effect on the flexor action the muscle exerts on the ankle joint.

The Flexor Hallucis Longus muscle varies in size, origin and insertion in the macaque, Orang and Man. In Rhesus monkey the muscle arises from the posterior surface of the head and almost the entire shaft of the fibula, from the intermuscular septum between it and the peroneal muscles, from the interosseous membrane, and in the lower half of the leg, from the lateral border of the tibia. The human muscle arises from the distal two-thirds of the posterior surface of the shaft of the fibula, from the fascia over it, and from the intermuscular fascia on either side. The rhesus origin is therefore much more extensive than the human

origin. Rhesus monkey takes up the head and almost whole of the shaft of the fibula, while Man only takes up the distal two-thirds of the fibula. The human muscle has no attachment to the interosseous membrane nor to the tibia, whereas the rhesus macaque enjoys a considerable attachment from both these sources. The Orang muscle arises by two heads - one Superficial, One Deep. The Superficial or Femoral head arises from the lateral margin of the popliteal surface of the femur, just proximal to the condyle, being deep and somewhat lateral to the origin of the lateral head of the Gastrocnemius. It also has attachment to the posterolateral portion of the Capsule of the knee joint. This belly is thick and elongated, covering most of the posterior surface of the deep belly, and eventually gives rise to a flat, thin, wide tendon which fuses with a dense aponeurosis on the distal portion of the deep head. The Deep head arises from the posterior and lateral surfaces of the head of the fibula, from the posterior surface of the proximal two-thirds of the shaft of the fibula, from the interosseous membrane, from the intermuscular septum separating it from the peroneal muscles, from the posterior part of the lateral ligament of the knee joint, and the lateral surface of the muscle gains considerable attachment from the extension of the insertion of Biceps femoris and from the deep fascia. Taken as a whole the Orang muscle is much bigger and more powerful than the rhesus muscle, which in turn is larger and more powerful, relatively, than the human muscle.

The tibialis posterior muscle arises, in the rhesus monkey, from the upper half of the posterior surface of the tibia, from the interosseous membrane and from the medial surface of the upper part of the fibula. The human muscle has origin from the proximal four-fifths of the medial surface of the body of the fibula between the medial crest and interosseous crest, from the

distal part of the lateral condyle and from the proximal two-thirds of the shaft of the tibia, distal to the oblique line and between the vertical line and interosseous border, from the interosseous membrane, from the fascia over it and the septa on either side.

Comparing these two origins it is apparent that the human, relatively, speaking, is more extensive than the rhesus, since it attaches to a greater area of the tibia and fibula than does the rhesus muscle. The interosseous membrane attachment must accordingly also be increased. The human muscle gains considerable origin from the over-lying fascia and septa on either side - attachments apparently not present in rhesus. The Orang muscle arises from the lateral and postero-lateral surfaces of the proximal one-third of the shaft of the tibia, from the posterior surface of the tibio-fibular joint, from the medial surface of the proximal half of the shaft of the fibula and, from the whole of the posterior surface of the interosseous membrane in the proximal half of the leg. The Orang origin tends to resemble that of rhesus quite closely, and is, therefore, also inferior to that of Man.

The Peroneus Longus muscle in rhesus monkey arises from the lateral intermuscular septum, the lateral aspect of the upper third of the shaft of the fibula, head of the fibula, and lateral aspect of the head of the tibia. The human muscle arises from the lateral condyle of the tibia, from the head and proximal two-thirds of the lateral surface of the body of the fibula, from intermuscular septa on either side, and from the dense fascia over it. The origin of the human muscle is, therefore, far more extensive than that of the rhesus muscle, having about twice as much bony origin from the fibula and also having stronger origin from the intermuscular septa and dense fascia overlying it. The Orang muscle arises from the antero-lateral and lateral surfaces

of the head of the fibula, the proximal half of the shaft of the fibula, from the intermuscular septum and finally from the dense fascia covering it. The human muscle, therefore, has a greater origin relatively than the orang muscle. The former has attachment to the tibia, the latter has not. Man's muscle arises from the proximal two-thirds of the shaft of the fibula, the Orang muscle from only the proximal half. The Orang muscle is, on the whole, more massive than the rhesus muscle due mainly to its greater fibular origin and attachment to deep fascia.

The Peroneus Brevis muscle appears to have the relatively greatest origin in Man, since in him it arises from the distal two-thirds of the fibula and from adjacent structures, while in Orang (and rhesus?) it arises only from the middle two-fourths of the fibula plus adjacent structures.

Reviewing the main plantar flexors first it is seen that Gastrocnemius is relatively equal in all three animals, but that Soleus is very much greater in Man than either in Orang or Rhesus monkey. It appears, therefore, that for the main flexors of the ankle Man is very definitely superior to either of the other two primates.

Considering the other muscles causing plantar flexion, it is seen that the superiority of the Orang's Flexor Hallucis Longus muscle is more than counter-balanced^d by the superiority displayed by the human's Tibialis Posterior, Peroneus Longus, and Peroneus Brevis muscles. The Flexor Digitorum Longus muscle was found to be relatively equal in all three animals. The superiority of the macaque's plantaris muscle is counter-balanced by Orang's superiority with Flexor Hallucis Longus and Peroneus Longus muscles, while it is more than counter-balanced^d by Man's superiority with Tibialis Posterior, Peroneus Longus and Peroneus Brevis muscles. These results merely confirm the impressions obtained

by a consideration of the main flexor muscles, that is, that Man is definitely best equipped for Plantar flexion of the ankle joint. Orang and Rhesus monkey have much less efficient equipment, and of the two Orang is possibly the stronger.

Inversion of the foot is brought about by the Tibialis Anterior and the Tibialis Posterior acting together. It has already been found that the former muscle is relatively equal in all three animals, while the latter muscle is relatively most powerful in Man, and about equal in Orang and the macaque. It follows, therefore, that inversion must be relatively most powerful in Man, and almost equal in Orang and Rhesus macaque.

Eversion of the foot is performed by the Peroneus Longus, Peroneus Brevis and Peroneus Tertius, this latter muscle appearing only in Man. Both Peroneus Longus and Brevis are relatively most powerful in Man - as seen above - and this, together with the Peroneus Tertius, makes Man definitely strongest at eversion of the foot. The Orang's Peroneus Longus muscle is a little more powerful than this muscle in the macaque, whereas the Peroneus Brevis is about equal in both.

Thus the Orang should have a slightly superior everting mechanism than the Rhesus monkey.

Now, reviewing the movements at the Ankle, it is apparent that Man clearly dominates all four fields of movement. This is what one could expect considering that the ankle is such an important joint in the orthograde posture of Man, requiring greater control in this position than in the pronograde or semi-pronograde posture of the Rhesus and Orang respectively.

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one group, the remaining lateral four digits being taken as another group. In Man these two groups are very closely united to form one functional unit - used for supporting the body in standing, walking and running. In the Orang and Macacus rhesus these two groups remain functionally separate so that the foot, besides being an organ for support, can also be used for grasping.

The Hallux can be dealt with by considering its three joints: (1) the joint between the medial cuneiform or entocuneiform and the first metatarsal: (2) the first metatarso-phalangeal joint: (3) the hallucial interphalangeal joint.

In the human foot the joint between the medial cuneiform and first metatarsal is made up by two almost flat articular surfaces, and besides the movements concerned with the functioning of the arches of the foot, there is almost negligible movement at this joint. In the Macacus rhesus foot and in the Orang foot, however, there is considerable movement at this joint. In these two animals the joint surfaces are not flat, but the articular surface of the medial cuneiform is convex, while the articular surface of the first metatarsal is concave. This tarso-metatarsal joint does not allow such freedom of movement as is enjoyed by the corresponding joint of the thumb, but, nevertheless, flexion, extension, abduction, adduction and opposition may be carried out. Flexion and extension are much more free than abduction or adduction, and opposition is fairly limited, especially in the Orang due to its reduced hallux. As to the movements at this joint need only be considered in the Macacus rhesus and Orang.

Adduction at this tarso-metatarsal joint is brought about by the Adductor Hallucis muscle. In the orang this muscle, - as I found it - was not easily divisible into transverse and oblique

heads. The muscle arose (1) from the bases of the second and third metatarsals, and from the tough ligaments lying between them; (2) from the dense membrane covering the interossei; (3) by a dense sheet of fascia from the midline of the shaft of the third metatarsal. This portion of the muscle probably represents the Oblique Head of the muscle. The Transverse Head arises from the distal one-quarter of the shaft of the second metatarsal bone, and from the medial halves of the plantar surfaces of the second and third Metatarsophalangeal joints.

The oblique head of the rhesus muscle arises from the common aponeurosis of the contrahentes muscles and from the bases of the second and third metatarsals. This compares fairly closely with the Orang origin, except that it does not extend as far distally as the orang muscle. The macaque muscle has its transverse head arising from the heads and joint capsules of the second, and less strongly, from the third metatarsal bone, from the medial border of the musculus contrahentes digiti IV and from the fascia over musculus contrahentes digiti II. This head again compares closely to the orang muscle - even to the point of having the stoutest attachment to the distal end of the second metatarsal bone (although this phenomenon is still more marked in the Orang).

So, as a whole, the Oblique head of the Orang muscle extends more distally in the foot than the muscle of the Rhesus muscle, and the two heads of the Orang muscle are much closer and much more difficult to separate than they are in rhesus.

The insertion in the Orang is into the lateral surface of the distal half of the shaft of the first metatarsal bone, and into the lateral aspect of the capsule of the first metatarsophalangeal joint, and the base of the sole phalanx of the hallux. The rhesus muscle inserts together with the lateral head of the musculus flexor hallucis brevis upon the lateral side of the

metatarso-phalangeal joint capsule and basal phalanx of the hallux, while deeper fibres insert upon the lateral aspect of the head of the hallucal metatarsal bone. The insertions are therefore similar, except that the muscle of Orang attaches to a much greater extent to the hallucal metatarsal.

The origin is somewhat greater in the Orang and also the bulk of the muscle is greater as compared to the muscle in rhesus. The fact that a good deal of this muscle in the Orang inserts into the shaft of the first metatarsal, enables this muscle to have much greater control over the tarso-metatarsal joint than is the case with the rhesus muscle. Thus, in the tarso-metatarsal joint, the Orang has definitely the stronger adducting force of the two animals.

The next movement, that of Abduction, is brought about by the abductor hallucis and Tibialis Anterior muscles. The former muscle is relatively very similar in the Rhesus macaque and Orang, arising from the medial surface of the posterior tubercle of the calcaneum and also to a great extent from the deep surface of the plantar aponeurosis. The insertion is the same in each: into the medial surface of the base of the proximal phalanx of the Hallux. The Tibialis Anterior has already been found approximately equal in Orang and Rhesus monkey. Thus, it may be concluded that abduction of the tarso-metatarsal joint is relatively equal in both Rhesus monkey and Orang.

Flexion of the joint is brought about by the Flexor Hallucis Longus, Flexor Hallucis Brevis, Peroneus Longus, and to some extent it is assisted by the Opponens hallucis.

The Flexor Hallucis Longus does not send a tendon to the hallux in the Orang, but serves only digits three and four. In the macaque, however, this muscle serves the hallux as well as digits three and four.

The Flexor Hallucis Brevis has a very similar origin in both rhesus macaque and orang. In the former it arises from the navicular bone and from the medial cuneiform bone (- the medial head; while the small lateral head also arises from the medial cuneiform). In the latter it arises from the medial cuneiform bone, from the medial portion of the sheath of Peroneus Longus, and also from the most anterior portion of the sheath of Tibialis Posterior. The muscle is not divided into two heads.

The Orang origin has thus moved slightly laterally in the foot. The rhesus muscle inserts by two tendons, one into the medial side and one into the lateral side of the base of the proximal phalanx of the hallux, the tendon of Flexor Hallucis Longus passing in between these two tendons. In the Orang the muscle gives rise to a short, single tendon which inserts into the plantar surface of the base of the sole phalanx of the hallux. The muscle must produce relatively about the same flexion force in each animal.

The Peroneus Longus due to its insertion into the lateral aspect of the base of the first metatarsal produces flexion in the macaque and Orang. (In Man the insertion of this muscle is not only into the base of the first metatarsal, but also into the medial cuneiform bone - a fact connected with the immobility of this joint in question, together with the support of the arches needed for a weight-bearing foot such as Man's). As has been described under the Ankle Joint, this muscle is relatively greater in the Orang than in the Rhesus macaque.

The Opponens Hallucis muscle assists at flexion to some degree. It appears normally only in the Orang-Utan.

Considering flexion now, it seems that the Flexor Hallucis Brevis is equal in the macaque and Orang. The Orang, however, is superior to the rhesus monkey in the Peroneus Longus muscle

and in having an Opponens Hallucis. But this superiority cannot match the strength supplied by the tendon of Flexor Hallucis Longus in the macaque - a tendon completely absent in Orang. So it must be concluded on this fact alone that the Rhesus monkey is relatively the stronger of the two at flexion.

Extension of the tarso-metatarsal joint is performed by Extensor Hallucis Longus, Extensor Hallucis Brevis, and Tibialis Anterior muscles. The Extensor Hallucis Longus muscle is very similar in both the macaque and Orang, and, as has been shown under the Ankle Joint, this muscle is almost equal in both these animals. Likewise, the Extensor Hallucis Brevis (or the medial belly of the Extensor Digitorum Brevis) is very similar and relatively equal in the Rhesus macaque and Orang. The final muscle, the Tibialis Anterior, is also very similar in both. So, altogether, the extensors of this tarso-metatarsal joint are about equal in the macaque and Orang.

Opposition is brought about by the Opponens Hallucis, the Peroneus Longus and also by the Adductor Hallucis. The former muscle appears only in the Orang, while the latter muscle, as seen above under "Adduction", is relatively greater in the Orang than in the macaque. Also the Peroneus Longus is more powerful in Orang than in Rhesus monkey. It seems definite, therefore, that the Orang is relatively more powerful at Opposition than is the Rhesus monkey.

Reviewing now the relative strengths of the various movements at the tarso-metatarsal joint in the macaque and Orang:

Adduction: Orang is the stronger:

Abduction: Orang and Rhesus macaque equal:

Flexion: Rhesus macaque is the stronger:

Extension: Orang and Rhesus macaque equal:

Opposition: Orang is the stronger.

The Orang is relatively stronger than the macaque at Adduction and Opposition of this tarso-metatarsal joint, while the rhesus macaque is relatively stronger than the Orang at Flexion of this joint, being equally strong at Abduction and Extension.

The next joint of the Hallux is the First Metatarso-Phalangeal Joint. It is capable of four movements:

(1) Adduction, (2) Abduction, (3) Flexion and (4) Extension.

This joint in the human foot can now be considered along with the joint in Orang's and Rhesus' foot.

Adduction is brought about by the Adductor Hallucis. This muscle was discussed under Adduction of the previous joint, and it was concluded there that the muscle was relatively stronger in the Orang than it was in the rhesus monkey. But this was so mainly because a great deal of the Orang muscle inserted into the first metatarsal itself, while the rhesus muscle inserted nearly completely into the base of the proximal phalanx of the hallux. This causes the rhesus muscle to make up for the stronger muscle of the Orang, and the two may be taken as exerting almost equal adducting force on this metatarso-phalangeal joint. The human adductor hallucis muscle has relatively greater origin than either rhesus or orang muscle. Its Oblique head arises from the sheath of peroneus longus, from the bases of the second, third and fourth metatarsal bones. The attachment to the base of the fourth metatarsal does not occur in either the macaque or Orang. The Transverse head arises from the capsules of the lateral four metatarso-phalangeal joints and from the transverse metatarsal ligament. This origin has extended much more laterally than is the case in the rhesus monkey or orang, in these two latter animals the origin extends no further than the third metatarso-phalangeal joint.

The insertion of the human muscle is entirely in the base of the proximal phalanx of the hallux - no power is expended on the first metatarsal bone as occurs in the macaque and more markedly in Orang. Thus it follows that the human muscle must have relatively greater force at Adduction at the first metatarso-phalangeal joint than either the rhesus monkey or orang, these latter two being about equal to one another in adduction of this joint.

Abduction is brought about by the Abductor Hallucis Brevis, a muscle which is very similar in origin, form and insertion in all three animals, so that abduction may be taken as being almost equal in the macaque, orang and man.

Flexion of the first metatarso-phalangeal joint is performed by the Flexor Hallucis Longus, and the Flexor Hallucis Brevis. As found under "Plantar-flexion of the Ankle Joint" the flexor hallucis longus is relatively stronger in rhesus monkey than in Man. But in the macaque the muscle supplies three digits while in man it supplies only the Hallux. Therefore it is really strongest for this digit in Man. It need not be considered for this joint in the Orang, as it does not give a tendon to the hallux in this animal. The Flexor ^Hallucis Brevis origin has migrated laterally in the foot of Man, since it arises from the medial part of the plantar surface of the cuboid bone, and from the tendon of tibialis posterior, while in rhesus it arises from the navicular and medial cuneiform, and in orang from medial cuneiform, tendon of tibialis posterior and medial part of sheath of Peroneus Longus. Thus Orang is intermediate between Rhesus monkey and Man. The Flexor Hallucis Brevis is relatively equal in the three animals. It follows, therefore, that Man must be most powerful of the three at flexion of the first metatarso-phalangeal joint, with the Rhesus macaque next, and Orang very

much the weakest.

Extension is brought about by the Extensor Hallucis Longus and Extensor Hallucis Brevis. As seen under the "Ankle Joint" the former muscle is relatively equal in rhesus monkey and orang, but stronger in Man. The latter muscle, as seen above, is relatively equal in all three. So, it follows that Man is greatest at Extension of the first Metatarso-phalangeal joint with the macaque and orang having about the same strength as each other for this action.

Thus the results obtained from this first Metatarso-phalangeal joint are:-

Adduction: Relatively greatest in Man; equal in rhesus monkey and orang.

Abduction: Relatively equal in all three.

Flexion: Relatively great in Man; then Rhesus monkey; weakest in Orang.

Extension: Relatively greatest in Man; equal in Rhesus monkey and Orang.

Man is, therefore, strongest at Adduction and Extension and Flexion of the first metatarso-phalangeal joint.

The inter-phalangeal joint of the Hallux occurs only in the macaque and Man, being normally absent in Orang. It has only two movements: Flexion and Extension.

Flexion is performed by Flexor Hallucis Longus, and as this muscle is devoted solely to the hallux in Man, while in rhesus it is divided between the hallux and digits three and four, it follows that the condition in Man must be relatively the stronger.

Extension is brought about by Extensor Hallucis Longus, and as found in the discussion on the ankle joint, this muscle is relatively stronger in Man than in Rhesus macaque.

Thus, Man is stronger than rhesus monkey in both movements of the inter-phalangeal joint of the hallux: - flexion and extension.

The hallux may be considered as a free and movable unit only in the foot of the macaque and Orang. From a study of the tarso-metatarsal joint the conclusion was arrived at that the Orang was relatively stronger than the macaque at Adduction and Opposition while the latter was relatively the stronger at flexion. This fits in with the habits of the respective animals; the Orang foot is used mainly for grasping, so that Adduction and Opposition are its two most useful movements; while the macaque foot is used for support in the pronograde posture and flexion is its most useful movement, since it can be used to adjust the balance of the foot by controlling the medial unit of the foot (the hallux). At the first metatarso-phalangeal joint the orang and macaque are relatively equal in all the movements except flexion, in which the macaque is again the stronger.

In Man the first metatarsal and the lateral four metatarsals are drawn firmly together, so that the hallux cannot be used as a free and separate unit of the foot. Its tarso-metatarsal joint is almost immobile when compared to the joint in rhesus monkey and orang. Adduction cannot be brought about at this joint in the human because the metatarsal is already fully adducted. In Man this muscle attaches to the distal phalanx of the hallux and has no direct connection with the first metatarsal as in rhesus and orang. This distal part of the hallux (the two phalanges) cannot be adducted very greatly, so the real function or at least the main function of the muscle - which is developed most greatly in Man as compared to rhesus monkey and orang - is to act on the ball of the foot, as the medial pillar of the foot - in much the same way as if the hallux were still free and would be the medial unit of the foot, - to balance the foot and to control the arches (the greater longitudinal and the Transverse Arches), so that the body weight is evenly distributed. It also forms an important

factor in controlling the ball of the foot in walking - since in walking the ball of the great toe plays such an essential part.

Abduction is also not found at the tarso-metatarsal joint in Man, but this muscle causes abduction of the two phalanges of the hallux, and this is important for balancing the weight of the body, especially in the step-off when walking.

Tibialis Anterior and Peroneus Longus cause extension and flexion respectively of the hallux in the macaque and orang. In Man these movements are not possible as such at the tarso-metatarsal joint, but these two muscles still act on this joint. They support and control the greater longitudinal arch of the foot, and since these are most important functions - as the balance of the weight of the body is also controlled to a very great extent by them - and since the tarso-metatarsal joint does not move excessively, the insertion of Peroneus Longus in Man has spread from the base of the first metatarsal on to the medial cuneiform, and the tendon of Tibialis Anterior is no longer split into two separate tendons as is the case in the macaque and orang. Man is strongest at all movements of the great toe - except Abduction, which is equal in all three. This enables him to have relatively greatest control over this medial pillar of the foot, a state of affairs to be anticipated when this medial pillar forms such an essential factor in the functioning of the foot as a weight-bearing organ in the upright posture of the human.

As regards the lateral portion of the foot - the lateral four digits - the metatarso-phalangeal joints will be first examined, then the proximal inter-phalangeal joints and finally the distal inter-phalangeal joints.

The metatarso-phalangeal joint is capable of four movements: Flexion, Extension, Abduction and Adduction.

Flexion is brought about by the Flexor Digitorum Longus;

Flexor Hallucis Longus; Flexor Digitorum Brevis; Flexor Digitorum Accessorius; Lumbricales and Interossei muscles.

The Flexor Digitorum Longus muscle is similar in power, relatively, in the Rhesus monkey, Orang and Man, since it has very similar origin and form in all three. The insertions, however, differ. In the macaque and orang the main insertions are into digits two and five. In Man the muscle supplies tendons of insertion into digits 2, 3, 4, and 5. Thus, digits two and five in the rhesus macaque and in Orang must have much greater power for flexion than these two digits in Man, since in the former two animals, the whole muscle is divided simply between the two digits, while in Man it goes to supply digits three and four, besides two and five.

The Flexor Hallucis Longus is relatively strongest in Orang, then in the macaque and finally weakest in Man - as seen under "Ankle Joint" above. The human muscle, however, inserts completely into the hallux, while in the macaque the muscle supplies digits 1, 3 and 4, and in orang digits 3 and 4. This accounts for Man having the strongest flexor action at the first metatarsophalangeal joint and at the inter-phalangeal joint of the hallux. This is again an important factor in balancing the foot to accept weight evenly, and also in supporting and controlling to some extent, the medial pillar of the foot - the ball of the great toe.

Digits 3 and 4 in the human are supplied by Flexor Digitorum Longus, a muscle which is already supplying digits 2 and 5, while in the rhesus monkey and orang the Flexor Hallucis Longus supplies digits 3 and 4. The orang is much stronger at flexion of digits 3 and 4 than the macaque, because in him the entire muscle is devoted to these two digits, whereas in the latter animal the muscle must also supply the hallux. Over and above this, the Orang muscle is much more powerful than the rhesus muscle.

It follows from a consideration of these main flexors, therefore, that Man is relatively strongest at flexion of the first digit while he is relatively weakest at flexion of the other four. Rhesus monkey and Orang are equally strong flexors of digits 2 and 5, and the Orang is relatively strongest at flexion of digits 3 and 4.

The Flexor Digitorum Brevis shows a transition from the macaque to Man with the Orang at an intermediate stage. In Rhesus monkey this muscle has two definite heads of origin - a large deep head from the tendon of Flexor Digitorum Longus, and a small superficial head from the plantar aponeurosis and medial portion of calcaneal tuberosity. In Orang there is a small, weak, vestigial deep head from the tendon of Flexor Digitorum Longus, and a large superficial head from the plantar aponeurosis and medial portion of the posterior tubercle of the calcaneum. In Man there is no deep head, but only a large superficial head - which may be divided into superficial and deep portions - which arises from the plantar aponeurosis and from the anterior part of the medial tubercle of the calcaneus. So here the elimination of the primitive portion of a muscle is witnessed, with the final complete establishment of the more modern part of the muscle.

The Superficial Head of the Rhesus muscle supplied digit 2, the Deep Head digits 3, 4 and 5.

The Superficial Head of the Orang muscle supplied digits 2, 3 and 4; the Deep Head digits 4 and 5, - the tendon to 4 joining the tendon of the Superficial Head to 4.

The human muscle supplied digits 2, 3, 4 and 5.

The tendons of the human and rhesus muscle insert into the base of the intermediate phalanx of the respective digit, whereas in the Orang the insertion is into the middle of the shaft of the intermediate phalanx of the respective digits. This fact, plus

away from it.

The metatarsals are relatively larger in the Orang's foot than either in the foot of rhesus monkey or Man, and so it must follow that the interossei must also be accordingly lengthened, and thus greater and relatively more powerful in the Orang than either in the macaque or Man.

Thus flexion at the Metatarso-phalangeal joints of the lateral four digits is undeniably strongest, relatively, in the Orang - especially as far as digits 3 and 4 are concerned, since its superiority has been shown with the Flexor Digitorum Brevis, the lumbricales and the interossei in addition to the main flexors, the Flexor Hallucis Longus and Flexor Digitorum Longus. The main flexors are relatively greater in rhesus macaque than in Man, but man makes up a little for this, as far as digits 2,3 and 4 are concerned, by having the best developed Flexor Digitorum Accessorius. The Flexion of the 5th digit is very much stronger in the macaque than man because besides having the main flexor - flexor digitorum longus - relatively stronger in rhesus monkey, this animal has its Flexor Digitorum Accessorius supplying digit 5 while in Man this muscle usually does not supply digit 5.

Extension of the metatarso-phalangeal joints is brought about by the Extensor Digitorum Longus and the Extensor Digitorum Brevis - the latter muscle being only concerned with the second, third and fourth joints. The extensor digitorum longus, as seen under the discussion on the Ankle Joint, is relatively equal in macacus rhesus, orang and Man. The second muscle, the extensor digitorum brevis, is slightly greater in the macaque and orang than it is in man, since in these two animals its origin is relatively more extensive than the origin of the human muscle. Therefore, though extension is almost equal in the three primates, the human is slightly weaker than either rhesus or orang at extension of the

digits 2, 3 and 4. Digit 5 must be equal for extension in all three.

Adduction and Abduction are brought about by the interossei, and these have already been dealt with above. These actions should be relatively greatest in the Orang due to his having the largest interossei.

The actions at the inter-phalangeal joints are flexion and extension. This latter action, being brought about mainly by the extensor digitorum longus, is about equal relatively in all three. The interossei and lumbricales are said to have very little action on the inter-phalangeal joints, so these will not influence the conclusion that extension of these digits is about equal in all three animals.

Flexion is relatively strongest in Orang, then in Rhesus monkey and finally weakest in Man - the same reasons holding here as above for the metatarso-phalangeal joints.

The two muscles of the fifth toe - the Flexor Digiti Minimi Brevis and Abductor Digiti Minimi are the only muscles of the foot not yet discussed.

The Abductor Digiti Minimi does not differ greatly in rhesus macaque, orang or man. It appears to have relatively greater origin in orang and man than in the macaque, but this is the only difference of note. The rhesus origin is from the tuber calcanei lateral to the abductor hallucis, and from the deep surface of the plantar aponeurosis. The Orang muscle arises from the lateral and adjoining plantar surface of the posterior part of the calcaneum, from the plantar aponeurosis, from the lower portion of the Inferior Peroneal Retinaculum, and from the fascia separating it from the Flexor Digitorum Brevis. The human muscle arises from the anterior part of both processes of the calcaneum and from the lateral portion of the plantar aponeurosis and the calcaneo-meta-

tarsal ligament and from the intermuscular septum between it and Flexor Digitorum Brevis.

The Flexor Digiti Minimi Brevis is almost identical in macaque rhesus and man, the origin in both being from the sheath of the peroneus longus and from the base of the fifth metatarsal bone. The origin is greater in the Orang, for not only does it take origin like the muscle in the macaque and man, but in addition arises from the lateral surface and the lateral half of the plantar surface of the shaft of the fifth metatarsal in its whole length. The insertion is the same in all three. This is rather in keeping with the general superiority at flexion found in the Orang in these lateral four digits.

Thus, summing up the results on the foot as a whole, it is seen that the foot of the rhesus macaque is not specialised in any one direction - it may be called still a generalised foot. Of all the movements the outstanding one is that of flexion - flexion of the hallux as well as flexion of the lateral four digits - a movement very useful in the arboreal haunts of this animal.

The Orang foot is notable for its relatively great strength for grasping - since the hallux was most powerful at Adduction and Opposition, while the lateral four digits are very decidedly the most powerful at flexion. (With these results in mind it seems anomalous that the Orang foot should have such a small and almost degenerate digit for Hallux).

Actually the grasping action of the Orang's foot is performed almost solely by the lateral four digits. The foot is markedly inverted and these lateral four toes are tightly flexed around the object grasped. The hallux really plays a minor role. Grasping performed by the Orang's hallux is rather a metatarsal movement and opposition and flexion are the two movements most involved. In contra-distinction to this the grasping movement of

hallux of Rhesus macaque is rather a digital movement in which adduction is the dominant action.

The human foot shows a very decided speciality for strength and support - since now the foot is no longer an organ for grasping but an organ for supporting the body's weight. The two functional units of the foot, as seen in rhesus and orang, are brought firmly together in the human foot for strength; the formation of arches, their support and control, forms the distinctive features of the foot of Man.

- S U M M A R Y -

At the hip joint the rhesus monkey is found to have flexion as the relatively strongest movement - a muscular mechanism very useful for the mode of progression adopted by this pronograde animal. Flexion and medial rotation are the two stronger movements of the knee joint, but these are relatively not as strong as in the Orang. They are about equal to these actions in Man's knee. The ankle joint is found to be not particularly strong in any one movement, and relatively, has much weaker forces controlling it than the human ankle. The foot of the macaque has its two functionally separate limbs: the medial formed by the hallux, and the lateral formed by the lateral four toes. In structure and function it is found to be quite a generalised foot.

The Orang has adduction, abduction and extension as the relatively strongest actions at the hip. These are all movements greatly used by this climbing arboreal animal. At the knee flexion and medial rotation are the strongest movements, and these are stronger, in relation, than those in the rhesus monkey or man. The ankle joint is not specialised in any one action, and on the whole, is very similar to the rhesus' ankle. The foot is equipped with an extremely powerful flexor mechanism in its lateral four toes, and this is not surprising, as flexion is the essential movement of a grasping organ, and the orang's foot is necessarily mainly a grasping organ.

Lateral and medial rotation are the two outstanding movements of the human hip joint, when the movements of this joint are compared to those of the Orang and the Rhesus monkey. These movements are more ^{valuable} ~~important~~ to the human because of the greater importance of his balancing on the lower limbs. Extension is relatively greatest in the human knee, and this action is the

essential one at the joint for upright posture. The ankle joint is very powerful in all its movements, much more powerful, relatively, than in Orang or in Rhesus monkey. This condition gives great control over the joint, and is a further mechanism calculated to enable Man to maintain his balance in the upright position. The foot is no longer in two separate units, but these have been adducted closely together to form an ingenious structure specialised for weight-bearing.

- C O N C L U S I O N -

This study has revealed how three primates with widely diverse habits, postures and modes of progression, all use the same basic muscle pattern with success. The muscles have adapted themselves in each case to perform with great efficiency the various functions required of them by the particular animal to which they belong.

In the *Macacus rhesus* both upper and lower limbs serve to support the trunk in the horizontal position and also act as instruments by which the animal can move rapidly in his arboreal haunts. It has been evident in this study that the muscle systems bringing about the movements which are most useful to this pronograde posture are particularly well developed.

The specialised arboreal anthropoid ape, the Orang-utan, has become a much larger and heavier beast, but is far less active. As upper limbs are more mobile, adaptable, and on the whole much more useful for an arboreal mode of existence than lower limbs, he has accordingly specialised in this direction by

attaining very long and tremendously powerful upper limbs, while on the other hand, his lower limbs have regressed considerably in size. The hands show remarkable adaptation for the animal's habits - especially that of suspending itself from branches by its upper limbs. They have become considerably lengthened, the metacarpals and phalanges are slightly curved and the insertions of the Flexor Digitorum Sublimis muscle have moved more distally on the respective phalanges to obtain greater leverage.

Man has become an orthograde terrestrial biped and as such we find that he is equipped with long and powerfully developed lower limbs which have special mechanisms for the balance of the body (such as the exceptional muscular control of the ankle), and special weight-bearing mechanisms (such as the arches of the foot) for supporting the whole weight of the body on the feet.

In conclusion, I wish to acknowledge my indebtedness to Prof. Raymond A. Dart, for the facilities granted me in his Department, and for providing an Orang-utan on which to conduct my research. I am very grateful to Dr. L.H. Wells for his constant encouragement, his kindly criticism and invaluable advice.

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- B I B L I O G R A P H Y -

Unfortunately, most of the older literature relating to the anatomy of the Orang-utan is not available to me in the original. For a summary of these articles I have relied on the works of Sonntag.

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Boyer, E.L. (1935): "The Musculature of the Inferior Extremity of the Orang-Utan, *Simia Satyrus*".
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Anat. Rec. 35: No. 3. p.193-239.

Other references used in the course of this work are:-

Cunningham's Text Book of Anatomy; 7th Ed., Oxford University Press.