We’ll look at the lower extremity in four sections. In this first section, we’ll look at the hip. After that we’ll look at the knee; then we’ll go down to the ankle, and lastly we’ll look at the foot.

Before we get started, there’s a simple term we need to define: the leg. In everyday speech, “the leg” means everything from the hip downwards. In anatomy, only this part, from the knee to the ankle, is the leg, and this part, from the hip to the knee, is the thigh.

In looking at the hip region, we’ll start with the bones, then we’ll look at the hip joint and how it moves, then we’ll look at the muscles which produce movement at the hip joint, and lastly we’ll look at the vessels and nerves. First, let’s see the bones.

Here are the lumbar vertebrae, the pelvis, and the two femurs. We’ll look at the pelvis by itself.

The pelvis is made up of the two hip bones, or innominate bones, and the sacrum. The fibrous joints which unite them, the two sacro-iliac joints behind and the pubic symphysis in front, permit almost no movement. We’ll look at the right hip bone by itself.

The hip bone is formed by the fusion of three bones, the ilium, the ischium, and the pubis. The names of these bones give rise to the names of the various features of the hip bone. Let’s look at these features.

This broad bony plate is the wing, or ala of the ilium. Its broad, roughened edge is the iliac crest, an area where many important muscles attach. The iliac crest ends in front at the anterior superior iliac spine, and behind at the posterior superior iliac spine.

This is the ischial spine, with the greater sciatic notch above it, and the lesser sciatic notch below it. This is the ischial tuberosity. The ischial tuberosity is another area where many muscles attach. It’s also the part of the hip bone that we sit on.

The socket for the hip joint is called the acetabulum. This broad smooth area is the articular surface. We’ll see it again in a minute with the articular cartilage intact.

The big hole in the lower part of the hip bone is the obturator foramen. This is the body of the pubis, this is the superior ramus of the pubis, and this is the ischio-pubic ramus. This prominence is the pubic tubercle, to which the inguinal ligament is attached.

It’s helpful to keep in mind that the upper part, and the lower part of the hip bone face in different directions, like my hands. If we look at the hip bone from in front, like this, we’re looking at the inner aspect of the ilium, and the outer aspect of the pubis and ischium. Now that we’ve looked at the hip bone, let’s bring the sacrum back into the picture. We’re looking at the bones as they’d be in the upright,
standing position, and it’s perhaps surprising to see the angle at which the sacrum lies. Its pelvic surface is more nearly horizontal than vertical.

The sacrum is attached to the hip bone not only by the sacro-iliac joint, seen here from behind, but also by two big ligaments, one going to the ischial spine, and one going to the ischial tuberosity, as we’ll see in a minute.

Now let’s add the femur to the picture. The femur is the longest bone in the body. We’ll be looking at its distal end in the next section. For now, let’s look at the features of the proximal end.

This is the head of the femur, this is the neck. Since the head is wide and the neck is narrow, the head of the femur can go a long way in this axis, and in this axis, before bone hits bone.

This prominent lump is the greater trochanter, and this one is the lesser trochanter. The greater and lesser trochanters are important muscle insertions. This line, the inter-trochanteric line, marks the insertion of a major ligament of the hip joint, which we’ll see in a minute. On the back of the femur this prominent ridge, the inter-trochanteric crest, runs from the greater to the lesser trochanter. This broad rough area is the gluteal tuberosity. This rough line running down the shaft of the femur is the linea aspera. Many muscles have their origins or their insertions on the linea aspera, on the gluteal tuberosity, and in this hollow in front of the intertrochanteric crest.

Now that we’ve looked at the dry bones, let’s see how they look in the living body. The big gap between the sacrum and the ischium is bridged by two massive ligaments. The sacro-spinous ligament goes to the ischial spine, the sacro-tuberous ligament goes to the ischial tuberosity. Let’s go round to the front and see those two ligaments from the inside. Here’s the sacro-spinous ligament, here’s the sacro-tuberous ligament. These two openings are the lesser sciatic foramen, and the greater sciatic foramen. The sciatic nerve passes through the greater sciatic foramen. The obturator foramen is largely closed by the obturator membrane. The obturator nerve and vessels pass through a small tunnel here.

Now let’s take a look at the hip joint. We’ll remove the femur for a moment, and look at the acetabulum. Here’s the broad, c-shaped articular surface, sometimes called the lunate surface. This non-articular part of the acetabulum is the acetabular fossa. Around the edge of the bony acetabulum this rim of fibrocartilage, the acetabular labrum, adds to the depth of the acetabulum.

This is the cut end of the ligament of the head of the femur. Its other end is attached here, on the center of the femoral head. Now let’s go back to the intact hip joint.

The capsule of the hip joint is a sleeve of ligaments. The capsule is thin on the underside. Everywhere else it’s thick and strong. This part of the capsule behind is called the ischio-femoral ligament. This anterior part of the capsule, which is the thickest, is known as the ilio-femoral ligament. The fibers of these capsular ligaments become tight when the joint is extended.

The capsule is attached to the hip bone all the way round the acetabular labrum. On the back of the femur the capsule is attached about halfway along the femoral neck. On the front of the femur the capsule is attached out here, on the intertrochanteric line.
Now let's take a look at the various different movements that occur at the hip joint. Movement can occur in three different axes. Forward movement is flexion, backward movement is extension. Movement out to the side is abduction, movement in toward the midline is adduction. Rotation outward is lateral rotation, rotation inward is medial rotation.

Rotation at the hip joint is accompanied by marked backward and forward movement of the greater and lesser trochanter.

Now we're almost ready to move on, to look at the muscles of the hip region. Before we do that, let's take a minute to review what we've seen of the bones, and of the hip joint. If you'd like to use this review section to test yourself, turn off the sound, and see how many of the structures you can name. There's another blue sign like this one, at the end of the review section.

**BONE AND JOINT REVIEW**

Here's the wing of the ilium, the iliac crest, the anterior superior iliac spine, the posterior superior iliac spine, the ischial spine, the ischial tuberosity, the acetabulum, the obturator foramen, the body of the pubis, the superior pubic ramus, the ischio-pubic ramus, and the pubic tubercle.

On the femur here's the head, the neck, the greater trochanter, the lesser trochanter, the inter-trochanteric line, the inter-trochanteric crest, the gluteal tuberosity, and the linea aspera.

Here are the sacro-spinous ligament, the sacro-tuberous ligament, the ischio-femoral ligament, the ilio-femoral ligament, and the obturator membrane.

**MUSCLES**

Now let's move on to look at the muscles that produce movement at the hip joint. There are five muscle groups to look at: the short rotators, the flexors, the adductors, and the extensors. We'll look at the six short rotator muscles first, because they lie deep to all the others.

The short rotator muscles arise from four different bony surfaces, the inner surface of the sacrum, both the inner surface and the outer surface of the area around the obturator foramen, and from the outer surface of the ischium. They all converge on this small area on the back of the femur, just medial to the greater trochanter.

The one that arises from the sacrum is piriformis. Here it is. Piriformis arises from here on the sacrum. It leaves the pelvis by passing through the greater sciatic foramen, along with the sciatic nerve. We'll go right round to the back to see where it comes out. Here's piriformis emerging. It inserts here, high up on the medial aspect of the greater trochanter.

Piriformis is an important muscle to understand, because it's closely related a very important structure, the sciatic nerve. Next we'll look at the two obturator muscles, obturator internus and externus. They lie on each side of the obturator membrane.
Here's obturator externus. It arises from the obturator membrane, and from the adjoining edge of the ischio-pubic ramus.

Obturator externus passes backwards just beneath the neck of the femur. Here's its tendon, passing laterally, to reach its insertion here, below piriformis.

Next we'll see obturator internus, which comes around the back of the ischium here, from inside the pelvis. We'll go around this way to see where it arises. Here's obturator internus. It arises from this wide area on the ilium and ischium, and from the obturator membrane. It leaves the pelvis through the lesser sciatic foramen. As it passes round the back of the ischium, obturator internus does a 90° turn.

As it makes the turn, it's joined above and below by these two little muscles, gemellus superior, and gemellus inferior. They arise from the ischium here, and here. Along with obturator internus, they're inserted here.

The last of the short rotators is quadratus femoris. Quadratus femoris arises from the ischial tuberosity here, and inserts on the femur here, on the intertrochanteric crest.

All these short rotator muscles have the same action: by pulling the back of the femur medially, they produce lateral rotation at the hip joint. When the foot is on the ground, the same muscle action produces what appears to be a different movement: rotation of the trunk to the opposite side. So contraction of these muscles has two possible effects, depending on whether the limb is free to move, or whether it's fixed. As we'll see, that's holds true for every muscle that produces movement at the hip joint.

Now we'll move on to look at the groups of muscles which produce adduction, and abduction at the hip. We'll look at the five adductors first. There are three named adductors, adductors magnus, brevis, and longus; and there are two other muscles which adduct, pectineus and gracilis.

The adducting muscles all arise from this region on the pubis and ischium, and they're all inserted along this line, the lowest, gracilis, right down here on the tibia. Let's start with the named adductors,

Here's the largest of the them, adductor magnus. Adductor magnus arises from the outer border of the ischio-pubic ramus. Its insertion is in two parts, with a gap in between. The upper part of adductor magnus inserts here, on the linea aspera. The lower part inserts here, on the adductor tubercle of the femur.

This gap is the adductor hiatus. The main blood vessels to the leg pass through here, from the front of the thigh, to the back.

The other two named adductors, brevis and longus, sit in front of adductor magnus. Here's adductor brevis. Here's adductor longus.

Brevis arises here on the body of the pubis, longus arises here. They're inserted on the femur right next to adductor magnus, brevis above, longus below. The insertion of adductor longus stops just short of the adductor hiatus.

The other two adducting muscles are a short muscle, pectineus, and a very long muscle, gracilis.
Pectineus is the shortest of the adductors. It arises from this line on the superior pubic ramus. It inserts here, just in front of adductor brevis.

Gracilis is the most medial of all the thigh muscles. It arises here on the pubis, and it’s inserted all the way down here, on the tibia.

The main effect of all these muscles, is to produce adduction at the hip joint.

The gracilis is the first muscle we’ve met which crosses both the hip joint, and the knee joint. We’ll be meeting more muscles like it quite soon. A muscle that crosses both the hip, and the knee can either act at the hip, at the knee, or at both joints at once. The movement that it does produce is determined by what other muscle groups are acting at the same time.

For now, when we look at a muscle that goes from above the hip to below the knee, we’ll just look at the way it acts at the hip. In the next section we’ll take a second look at each of these muscles, and see how it acts at the knee.

Now let’s move on, and look at the three muscles which produce abduction at the hip joint. The two important abductors are gluteus minimus, and gluteus medius. We’ll go round to the back to look at them.

Here are the short rotator muscles that we’ve seen already, quadratus femoris, obturator internus and the gemelli, and piriformis. Now we’ll add gluteus minimus to the picture. Gluteus minimus arises from this part of the wing of the ilium. It’s inserted here, on the front of the greater trochanter.

Overlying gluteus minimus, is gluteus medius. Gluteus medius arises from this part of the ilium. It’s inserted here, on the outer aspect of the greater trochanter.

Though gluteus medius is mainly an abductor as we’ll see, its anterior part also produces medial rotation at the hip.

The last of the abductors is called the tensor fascia lata. Before we look at it, we need to digress for a minute, and get acquainted with the structure that gives it its name, the fascia lata.

The fascia lata is a continuous sheet of dense fibrous tissue that surrounds all the muscles of the thigh. Along the outer aspect of the thigh there’s a very marked thickening of the fascia lata called the ilio-tibial tract. It extends all the way from here on the ilium, down to here, on the tibia.

Here’s the ilio-tibial tract by itself, with the rest of the fascia lata removed. These muscles, in front of it and behind it, we’ll be looking at in a minute. Between the muscles is a strong fibrous septum, which attaches the ilio-tibial tract to the femur. At its lower end, the ilio-tibial tract is attached down here on the tibia.

The ilio-tibial tract acts as the tendon of insertion of two muscles, a big one back here, gluteus maximus, which we’ll see later, and this one, which we were just getting ready to look at, tensor fascia lata.

Tensor fascia lata arises from the iliac crest here. It inserts here on the ilio-tibial tract.
The three hip abductors move the limb to the side. When the foot is on the ground the hip abductors, pulling down on the ilium, raise the opposite side of the pelvis up. This tilting of the pelvis happens in a small way each time we take a step, making it easy for the opposite foot to move forward without touching the ground.

Now let's move on to look at the muscles which produce flexion at the hip. There are four, two that act only at the hip, and two that act at the hip and also at the knee. The first two are the most important hip flexors - they're called iliacus, and psoas major.

Iliacus arises here from the iliac crest, psoas major from all the way up here, on the lumbar spine.

Here's psoas major. Psoas major arises from the transverse processes of all five lumbar vertebrae, and from the sides of the intervertebral discs and the adjoining vertebral bodies. We'll see its insertion in a moment.

Here's iliacus. It arises from almost all of the inner aspect of the wing of the ilium.

As they pass downward together, iliacus and psoas major pass over the superior pubic ramus and under a structure here that we haven't been introduced to yet, the inguinal ligament.

The two muscles pass downward and backward, and insert together down here, on the lesser trochanter. Contraction of the iliacus and psoas major produces flexion of the hip joint.

When the limb is free to move, flexion brings the thigh forward. When the limb is fixed, as it is here, flexion of both hips brings the body upright.

The other two muscles which help in hip flexion are rectus femoris, and sartorius. They're more important for their actions at the knee, than for their actions at the hip. We'll look at them briefly here, and in more detail in the next section. Rectus femoris is part of a huge muscle with four heads called quadriceps which we'll see in a moment.

Here are the muscles that we've seen already: psoas major and iliacus, pectineus, adductor brevis, longus, and magnus, and gracilis. Now let's add quadriceps to the picture.

All this is quadriceps. It's the main muscle that extends the knee. The only part of quadriceps which acts as a hip flexor is this part, rectus femoris. Its the only part that arises from above the hip joint, which is here.

Rectus femoris arises by two heads here and here, just above the acetabulum. Its final insertion, along with the other three heads of quadriceps, is right down here on the tibia. Rectus femoris is quite a weak hip flexor.

Now we'll add the last hip flexor, sartorius. Sartorius is a very long narrow muscle that lies outside all the others. It runs in a spiral, starting here on the anterior superior iliac spine, and ending up all the way down here, on the tibia. Sartorius helps to flex the hip. It can also produce lateral rotation at the hip.

Now let's move on to look at the four muscles that extend the hip. The first three, which are known collectively as the hamstring muscles, act at the hip and at the
knee. The fourth one, gluteus maximus, acts only at the hip. We’ll come to it last because it lies outside the others and covers them up

Here’s the back of the thigh as we saw it last. Here’s gluteus medius, here are all the short rotators, here’s adductor magnus, and here’s the back of quadriceps.

The three hamstring muscles all arise from the ischial tuberosity. Here they are. Two of them run down to the medial aspect of the leg, one runs to the lateral aspect. The lateral one is biceps femoris. The two medial ones are semimembranosus, and semitendinosus.

Here’s semimembranosus by itself. It has a long flat membrane-like tendon of origin, which arises from here on the ischial tuberosity. It’s inserted here on the back of the tibia.

Here’s semitendinosus, lying behind semimembranosus. It has a long cord-like tendon of insertion. It arises from here, next to semimembranosus. It inserts down here on the medial aspect of the tibia, close to two other muscles that we’ve seen already, sartorius and gracilis.

Now that we’ve seen these two, we’ll add biceps femoris to the picture. Biceps femoris has two heads of origin, a long head, and a short head.

The long head arises from here on the ischial tuberosity, along with semitendinosus. The short head arises from almost the whole length of the linea aspera, and from this supracondylar line.

The two heads of biceps femoris join together, forming a tendon that runs down behind the lateral aspect of the knee, then runs forward to insert here, on the head of the fibula.

We’ll be taking another look at the hamstring muscles, their insertions, and their actions at the knee, in the next section. We’ll look at their action at the hip in a minute, but before we do that we’ll add the last and largest of the hip extensors, gluteus maximus, to the picture.

Here’s the upper end of the hamstring muscles, here, overlying them, is gluteus maximus. It’s a thick, flat sheet of muscle. Gluteus maximus arises from here on the back of the ilium, and from the side of the sacrum, and from the sacrotuberous ligament.

The upper three quarters of gluteus maximus inserts into the ilio-tibial tract. The lower one quarter of gluteus maximus passes more deeply, and inserts here on the back of the femur, on the gluteal tuberosity.

Now let’s look at the actions of the hip extensor muscles, starting with the hamstring muscles. Contraction of the hamstring muscles can produce both knee flexion, and hip extension. When knee flexion is held in check by the action of quadriceps, the hamstrings just produce extension at the hip, which is the action that propels us forward in normal walking.

Gluteus maximus isn’t used in the gentle action of normal walking. It comes into play when a powerful action is needed, especially an action that opposes the force of gravity. The action of gluteus maximus extends the hip from a position of full flexion, as in climbing stairs, or rising from a squatting or sitting position. The
same action, balanced against the force of gravity, controls the rate of hip flexion, as we sit down.

Gluteus maximus is one of the two big anti-gravity muscles of the lower extremity. The other one, acting at the knee, is quadriceps as we’ll see in the next section.

Gluteus maximus has yet another set of actions when the lower extremity is fixed and upright. Then the action of gluteus maximus pulls the back of the pelvis downward, raising the body from a forward bend at the hips, or, when balanced against gravity, controlling the rate of bending forward.

Now we’ve looked at all the muscles that produce hip movement. As we’ve seen, several of them also have important actions at the knee, and we’ll be looking at these a second time in the next section. We’re now almost ready to move on, to look at the vessels and nerves of the hip region, but before we do that, let’s review what we’ve just seen of the muscles.

REVIEW

Here’s gluteus maximus, biceps femoris, semitendinosus, and semimembranosus.

Here’s gluteus medius, and gluteus minimus.

Here’s piriformis, obturator internus, and quadratus femoris; and here’s adductor magnus, seen from behind.

On the front, here’s tensor fascia lata, sartorius, and rectus femoris, psoas major, and iliacus, pectineus, adductor brevis, adductor longus, and magnus, and gracilis, and here again are piriformis, obturator internus, and obturator externus.

BLOOD VESSELS

Now we'll move on, and look at the blood vessels and nerves of the hip region. We'll follow the course of the vessels and nerves from the inside of the body, to the proximal part of the thigh. In the next section we'll follow them on down to below the knee. To understand the course of the main blood vessels, the femoral vessels, there's a structure we need to look at, that we saw before, the inguinal ligament; and there's a space between muscles that we need to understand, called the femoral triangle.

Here's the inguinal ligament. It's a strong, tight band that forms the lowest part of the anterior abdominal wall. The inguinal ligament passes from the anterior superior iliac spine, to the pubic tubercle. The inguinal ligament isn't an isolated structure, it's the lower edge of this large sheet of tendon-like material, the external oblique aponeurosis. Here's the inguinal ligament. The fascia lata, which we've seen already, is attached to it along here.

Tha gap between the inguinal ligament and the superior pubic ramus is occupied partly by the iliacus and psoas muscles, and partly, as we'll see, by the femoral nerve, artery and vein, and the inguinal lymph nodes. The other muscle in the picture here is obturator externus.
Now let's add all the other thigh muscle to the picture, and see the femoral triangle. Here, the fascia lata has been left intact; here, it's been removed. The femoral triangle is the name given to this deep hollow. It's bounded by sartorius laterally, adductor longus medially, and the inguinal ligament above. In the depths of the triangle pectineus, psoas major and iliacus pass backward toward their insertions.

Now that we understand the inguinal ligament and the femoral triangle, we can move on and look at the blood vessels in the hip region, starting with a brief look at the principal veins. Almost all the veins in the region run parallel to arteries of the same name, so we won't need to look at them all separately. There's just one important vein we do need to look at, that has no corresponding artery - the long saphenous vein, also called the greater saphenous vein. With the main vein there's a change of name that we need to understand. Below the inguinal ligament it's called the femoral vein. Above the inguinal ligament it's called the external iliac vein. It's the same with the artery. The vessels themselves don't change, just their names.

Here's the thigh with just the skin removed. The anterior superior iliac spine is here. Here's the long saphenous vein, which starts at the ankle, and passes up the medial side of the knee, and up to the top of the thigh. We'll remove all the subcutaneous fat to see it better. The inguinal ligament runs from here to here. Here's the fascia lata. Superficial veins from other parts of the region join the upper end of the long saphenous vein which passes through an opening in the fascia lata, the saphenous hiatus. Here, near the top of the saphenous vein are two of the inguinal lymph nodes. The main lymphatic vessels draining the lower extremity pass under the inguinal ligament here.

To see where the saphenous vein goes, we'll remove the fascia lata, and the underlying fat. Here are the main blood vessels to the leg - the femoral vein, and artery, and this is the femoral nerve. The long saphenous vein ends by joining the femoral vein here.

The femoral vein passes beneath the inguinal ligament. To see where it goes, we'll remove the abdominal wall, leaving just the inguinal ligament. This is the inguinal ligament, this is the top of the pubis. Here the vein is called the femoral vein, here above the inguinal ligament it's the external iliac vein; it's all the same vessel. To see where it goes, we'll remove the artery.

This muscle is the psoas major muscle. The external iliac vein is joined by the internal iliac vein to form the common iliac vein. The right and left common iliac veins join in the midline to form the inferior vena cava.

Now we'll remove all the veins from the picture so that we can look at the arteries. We'll look first at the internal and external iliac arteries. Then we'll look at the femoral and deep femoral arteries which supply almost all of the lower extremity; then we'll look at the gluteal arteries which supply the gluteal or buttock area.

Here's the abdominal aorta, dividing to give off the left and right common iliac arteries. The common iliac divides, into the internal iliac and external iliac arteries. The external iliac passes under the inguinal ligament, emerging as the femoral artery.
The femoral artery gives off two small branches and one large branch. The small branches are the superficial circumflex iliac, which runs laterally, and the external pudendal, which runs medially. The large branch is the deep femoral artery, which we'll look at in a minute. The femoral artery itself runs downward, and passes beneath the sartorius muscle. We'll follow its further course in the next section of this tape.

Below the point where it gives off the deep femoral, the femoral artery is often referred to as the superficial femoral. It supplies everything from about here downward, but the main artery that supplies the thigh is the deep femoral.

To follow the deep femoral artery, we'll remove the femoral artery. We'll also remove the sartorius muscle and the femoral nerve.

Early in its course, the deep femoral gives off two large branches, the medial circumflex femoral, and the lateral circumflex femoral. It then passes behind adductor longus, which we'll remove.

Here's pectineus, adductor brevis, adductor magnus, rectus femoris. The deep femoral artery runs down in front of adductor brevis and adductor magnus, giving off numerous muscle branches, including several which run backward through adductor magnus to supply the posterior thigh muscles.

Now we'll go up to the internal iliac artery again, to look at the gluteal vessels, which provide the blood supply for the buttock.

The left side of the pelvis has been removed to give us a better view. Here's the internal iliac artery. Its branches which go to the pelvic viscera have been divided. Here, arising from the internal iliac, are the superior gluteal and inferior gluteal arteries. They both pass backward through the greater sciatic foramen, one above and one below the piriformis muscle, which is here. To see where they emerge, we'll go right round to the back, and remove gluteus maximus.

Here's piriformis, here's gluteus medius. Again, all the veins have been removed to simplify the picture. Here's the superior gluteal artery, and here's the inferior gluteal artery, branching to supply the muscles of the buttock region.

NERVES

Now that we've looked at the blood vessels of the hip region, we can move on to look at the nerves. We'll look first at the femoral nerve and the obturator nerve, which supply the front and the medial aspect of the thigh, then we'll look at the gluteal nerves and the sciatic nerves, which supply the buttock and the back of the thigh. All the nerves of the lower extremity come from the anterior rami of the second to the fifth lumbar nerves, and the first, second and third sacral nerves. To see where these arise, let's take a look at the lumbar spine and the sacrum.

Below each vertebra there's an intervertebral foramen. An anterior ramus emerges through each foramen. The anterior rami of the sacral nerves emerge from the anterior sacral foramina. Each anterior ramus is numbered according to the vertebra, or the sacral segment, that's above it. Here's the third lumbar vertebra, here's where the L3 ramus emerges.
We’ll start by looking at the femoral nerve, and the obturator nerve. This is the femoral nerve, this is the obturator nerve. The white structure between them is the psoas major tendon. Both these nerves arise from the lumbar plexus, which lies up here within the thickness of the psoas major muscle.

The femoral nerve emerges lateral to psoas major, the obturator nerve medial to it. We’ll follow the femoral nerve. It runs across the iliacus muscle, and passes under the inguinal ligament just lateral to the femoral artery. Below the inguinal ligament the femoral nerve breaks up into several branches.

The femoral nerve supplies iliacus, all four heads of quadriceps, and also pectineus, and sartorius.

Now lets look at the obturator nerve. Emerging below the medial border of psoas major, it crosses the wing of the sacrum, then runs along the back of the ischiopubic ramus. It leaves the pelvis by passing forward through the obturator canal, just above obturator internus. To see where it emerges, we’ll remove pectineus.

Here’s the obturator nerve, emerging over the top of obturator externus. Its branches run down between the adductor muscles. The obturator nerve supplies obturator externus, adductor brevis, and longus, and the anterior part of adductor magnus.

Now we’ll look at the two gluteal nerves, the superior and the inferior, and at the largest nerve of the lower extremity, the sciatic nerve, which supplies the posterior thigh muscles, and also almost everything below the knee. The gluteal and sciatic nerves arise from the sacral plexus.

Here’s the sacral plexus. It’s formed by the anterior rami of L4 and 5, and S1.2 and 3. The sacral plexus overlies the piriformis muscle.

This is the sciatic nerve. It arises from L4 through S3. This is the superior gluteal nerve. The inferior gluteal nerve arises out of sight behind the sciatic nerve. All three nerves leave the pelvis through the greater sciatic foramen. To see where they come out, we’ll go round to the back, and remove gluteus maximus.

Here, the vessels have been removed to simplify the picture. Here’s piriformis. Here’s the sciatic nerve, here’s the inferior gluteal nerve, and here’s the superior gluteal nerve, disappearing beneath gluteus medius. The superior gluteal nerve supplies gluteus medius, gluteus minimus, and tensor fascia lata. The inferior gluteal nerve supplies gluteus maximus.

The sciatic nerve runs down the middle of the thigh. Deep to it are quadratus femoris, and lower down, adductor magnus. This is the long head of biceps femoris which crosses over the nerve obliquely, and covers it up. We’ll follow the sciatic nerve further, in the next section of this tape.

In the thigh, the sciatic nerve supplies semitendinosus, semimembranosus, and also biceps femoris, and the posterior part of adductor magnus.

Lastly, there are a few hip muscles which have their own individual nerve supply. Psoas major is supplied by several small branches of the lumbar plexus. Small separate branches of the sacral plexus supply piriformis, obturator internus, and quadratus femoris.

Now let’s review the vessels and nerves of the hip region.
REVIEW

Here’s the long saphenous vein, and the femoral vein, becoming the external iliac vein.

Here’s the common iliac artery, the internal iliac, giving off the superior gluteal and inferior gluteal arteries. Here’s the external iliac, becoming the femoral artery.

Here’s the superficial circumflex iliac, and the external pudendal. Here’s the deep femoral, giving off the lateral circumflex femoral, and the medial circumflex femoral arteries.

Now the nerves: the femoral nerve, the obturator nerve, the sciatic nerve, the inferior gluteal nerve, and the superior gluteal nerve.

That brings us to the end of this section on the hip region. In the next section we’ll look at the knee.

END OF SECTION 1
PART 2: THE KNEE

BONES, LIGAMENTS AND JOINTS

In this section, we’ll look at the knee. First we’ll look at the bones, then the knee joint and how it moves, then the muscles that move it, and lastly the vessels and nerves. Let’s see the bones, starting with the femur.

We saw the proximal end of the femur in the last section. Now let’s look at the distal end.

The two smoothly curved surfaces are the lateral condyle and the medial condyle. The deep notch which separates them is the intercondylar notch. Above the two condyles are the epicondyles, lateral and medial. The sharp corner on the medial epicondyle is the adductor tubercle. This prominent ridge is the medial supracondylar line, this one is the lateral supracondylar line. Now we’ll add the tibia and the fibula to the picture.

The tibia and the fibula are fixed to each other firmly by two joints, the proximal, and distal tibio-fibular joints. There’s almost no movement at either of these joints. Let’s take a look at the proximal end of the tibia.

This is the medial condyle, this is the lateral condyle. On top of the two condyles are two quite separate articular surfaces. They’re much flatter than those on the femur. The rugged expanse between the articular surfaces is the inter-articular area. This prominent lump on the front, the tibial tubercle, is the final insertion of the quadriceps tendon. The small facet under here is for the fibula, which we’ll add.

This is the head of the fibula, this is the neck. The head of the fibula is the point of attachment of a major ligament of the knee joint, as we’ll see.

The space on each side of the knee between the femoral condyle and the tibial condyle is occupied by a crescent shaped piece of cartilage, a meniscus, which we’ll see shortly. The space in the middle, the intercondylar notch is occupied by the two cruciate ligaments. The intercondylar notch and its contents divide the knee joint into two almost separate halves.

There’s one more bone to add to the picture, the patella, or kneecap. The patella, as we’ll see, is embedded within the quadriceps tendon, which comes from up here, and inserts on the tibia down here on the tibial tubercle. On the back of the patella the articular surface is divided into facets. These articulate either with the femoral condyles when the knee is flexed, or with this central articular area when it’s extended.

Now that we’ve seen the bones of the knee joint, let’s see how the joint looks in the living body.

In building up our picture of this quite complicated joint, there are several structures that we need to understand: first the two joint cartilages or menisci, then the ligaments, the two cruciate ligaments and the two collateral ligaments, then the patella and the quadriceps tendon on the front, and lastly the capsule which encloses the joint.
Here are the two articular surfaces of the tibia. The two menisci sit on top of them. Here are the menisci. They’re made of flexible fibrocartilage. They’re shaped a little differently, the lateral one is almost a circle, the medial one is more C-shaped. In cross section, each meniscus is thick at the outer edge and thin at the inner edge. The two ends of each meniscus are attached to the inter-articular area of the tibia, the medial ones far apart, the lateral ones close together.

In addition each meniscus is attached all the way round its edge, both above and below, to the joint capsule. Here’s part of the joint capsule. We’ll see more of it later.

The lateral meniscus is much more mobile than the medial one, partly because its two ends are attached close together, partly because of a big difference in the mobility of the joint capsule around the edge.

By filling in the spaces between the femoral and tibial condyles, the menisci produce an even distribution of synovial fluid, to nourish and lubricate the articular cartilage of the femur and tibia. Now let’s look at the two pairs of ligaments which hold the bones together at the knee joint - the two cruciate ligaments on the inside, and the two collateral ligaments on the outside.

We’ll look at the cruciate ligaments first. They’re the important structures which prevent forward and backward movement of the femur on the tibia. Their name comes from the fact that they form a cross like this.

Here’s the anterior cruciate ligament, seen from in front. Here’s the posterior cruciate ligament, seen from behind. To get a better look at them, we’ll remove the lateral condyle of the femur.

Now we can see the whole of the anterior cruciate ligament. The anterior cruciate ligament goes from here on the tibia, to here on the femur, on the inner aspect of the lateral condyle. The anterior cruciate ligament prevents the femur from moving backward in relation to the tibia.

Now we’ll look at the posterior cruciate ligament. We’ll remove the anterior cruciate ligament to see it better. The posterior cruciate ligament goes from here on the femur, to here on the back of the tibia. The posterior cruciate ligament stops the femur from moving forward on the tibia.

By preventing backward and forward movement, the cruciate ligaments ensure that the condyles of the femur stay in one place, as they roll on the condyles of the tibia. Without them, the femur would roll off the back of the tibia in flexion, and would roll off the front of it in extension.

Now let’s look at the two collateral ligaments, the fibular collateral ligament on the lateral side, and the tibial collateral ligament on the medial side. The tibial collateral ligament goes from the medial epicondyle of the femur, to the anteromedial aspect of the proximal tibia.

The tibial collateral ligament blends with the capsule of the knee joint behind, and also in front. On its inner aspect, it’s firmly attached to the edge of the medial meniscus, which is here. Now let’s look at the rather different fibular collateral ligament. It goes from the lateral epicondyle of the tibia, to the head of the fibula.
The fibular collateral ligament stands out from the side of the knee joint. Unlike its tibial counterpart, it doesn’t blend with the joint capsule. It’s not attached to the meniscus.

When the knee joint is extended, both the collateral ligaments are tight. When it’s flexed, they become less tight. The function of the collateral ligaments is to keep the femoral and tibial condyles together, and thus to prevent the knee joint from bending from side to side like this, or like this.

In addition to the obvious knee movements - flexion and extension - it’s also possible for the tibia to rotate a little on the femur, like this. This rotation can happen only when the knee is flexed - when it’s extended the tightness of the collateral ligaments makes rotation impossible. The next structure we need to add in building up our picture of the knee joint is the quadriceps tendon, and along with it, the patella.

Here’s the distal end of the quadriceps muscle, which we’ll see in more detail later in this section. Here’s the quadriceps tendon. The patella, which is here, is enfolded within the tendon. The part of the tendon below the patella is known as the patellar ligament. On the medial side, and on the lateral side, the tendon is continuous with the capsule of the knee joint.

Between the quadriceps tendon and the femur is an extension of the knee joint cavity, the quadriceps bursa. It’s lined with synovial membrane. This lubricated pocket enables the quadriceps tendon to slide easily on the femur.

Now we’ll complete our picture of the knee joint by adding the fibrous capsule which encloses it.

Here’s the knee joint with the joint capsule intact. On the medial side the thin capsule is continuous with the tibial collateral ligament, but on the lateral side the capsule is separated from the fibular collateral ligament. On the back of the joint the capsule is thick and strong. The thickened posterior capsule prevents hyperextension of the knee joint.

Here we’ve divided the fibrous capsule to see its inner surface. It’s lined on the inside with synovial membrane all the way round the joint, except at the back. At the back, as we’ll see if we remove the capsule, the thin synovial membrane (here it is) passes forwards around the cruciate ligaments, covering them on the front.

Besides being the largest joint in the body, the knee joint is also much the most complicated! Before we move on to look at the muscles which produce knee movement, let’s review what we’ve seen of the bones, and of the knee joint.

REVIEW

On the femur, here’s the lateral condyle, and epicondyle; the medial condyle, and epicondyle; the adductor tubercle, and the intercondylar notch.

On the tibia, here’s the lateral condyle, the medial condyle, the tibial tubercle, and the facet for the fibula.
Here's the head of the fibula, the neck of the fibula, the proximal tibio-fibular joint, and the patella.

Here's the medial meniscus, the lateral meniscus, the anterior cruciate, and posterior cruciate ligaments. The fibular collateral ligament, the tibial collateral ligament, the quadriceps tendon, the patellar ligament, and the joint capsule.

**MUSCLES**

Now we’ll move on to look at the muscles which produce movement at the knee joint. We’ve met most of them already. The one muscle that extends the knee is the massive quadriceps. We saw it briefly in the last section. We’ll take a better look at it now. The main flexors of the knee are the so-called hamstring muscles, semi-membranosus, semitendinosus, and biceps femoris. Besides flexing the knee, the hamstring muscles also extend the hip. We took a good look at them in the last section. Here, we’ll just re-visit their insertions. In addition we’ll look at three muscles at the back of the knee that we haven’t yet seen - popliteus, gastrocnemius, and plantaris.

We’ll start with quadriceps. Its name comes from the fact that it has four heads. Oddly, these are named as though they were separate muscles. Three of the heads arise from the femur. They’re all called vastus intermedius, vastus medialis, and vastus lateralis. The fourth head, rectus femoris, arises from the hip bone. All four heads converge on the quadriceps tendon, which we’ve seen. We’ll start with the deepest of the heads, vastus intermedius.

Here it is. It forms a bulge on the front of the femur. Vastus intermedius arises from this broad area around the lateral aspect and front of the femur.

Wrapped around the outside of vastus intermedius are vastus medialis, and vastus lateralis. These two cover vastus intermedius almost completely. Their fibers run obliquely, all the way round to the back. Here’s lateralis, here’s medialis, almost meeting it.

Vastus lateralis arises from the lateral edge of the linea aspera, and from the side and front of the greater trochanter. Vastus medialis arises from the medial edge of the linea aspera, and from just below the lesser trochanter. The thin strip of bone between these two lines of origin provides the insertion of all the adductor muscles, and also the origin of the short head of biceps.

Now let’s add rectus femoris to the picture. Here it is. Rectus femoris arises from the ilium just above the hip joint. Its tendon of origin has two parts, a posterior or reflected part and an anterior or straight part. The anterior part arises from this prominence, the anterior inferior iliac spine. The posterior part arises from just above the acetabulum.

All four heads of quadriceps converge on the quadriceps tendon. The lowest fibers of vastus lateralis and medialis insert into the sides of the patella.

The principal action of the quadriceps muscle is to extend the knee. When the foot is off the ground, that action simply straightens the leg, and holds it straight. When the foot is on the ground, the action of quadriceps has several important effects.
In normal walking, quadriceps straightens the leg as the foot reaches the ground, then keeps the leg straight while the hamstring muscles extend the hip.

Quadriceps is also one of the two big anti-gravity muscles of the lower extremity. Its partner, which we’ve seen already, is gluteus maximus. Acting together, quadriceps at the knee and gluteus maximus at the hip, lift the body upward, when we climb uphill, when we rise from a sitting position, and when we jump. The same muscle actions propel us forward when we’re pushing a heavy load.

In addition to these actions, when quadriceps and its partner gluteus maximus act in balance with the force of gravity, they control our rate of descent as we sit down, and also when we walk downhill.

We need to digress for a moment to look at a structure called the adductor canal, which lies between vastus medialis, and the adjoining adductor longus muscle. The adductor canal is important because the femoral vessels run through it, in their course from the front of the thigh to the back.

Here’s vastus medialis, here are the adductor muscles, magnus behind, longus in front, with brevis up here. The adductor canal is formed by the groove between adductor longus and vastus medialis, and by this sheet of fascia, called the roof of the adductor canal, which bridges over between the muscles. The adductor canal is covered over by the sartorius muscle.

We’ll see the adductor canal again when we look at the blood vessels. Now let’s move on to look at the muscles which produce flexion at the knee joint. We’ll revisit the main flexors, the three hamstring muscles, and two minor flexors, sartorius and gracilis.

Here are the hamstring muscles again. On the medial side, here are semi-membranosus and semi-tendinosus. As we’ve seen, they both arise from the ischial tuberosity and insert on the medial side of the knee, semimembranosus here, semitendinosus here.

On the lateral side, here’s biceps femoris. It arises both from the ischial tuberosity, and from the femur, and inserts down here, on the head of the fibula.

We’ve already seen that these three muscles, which usually act together, can produce either extension of the hip, or flexion of the knee. Whether they do one, the other, or both, is determined by what other muscles are acting in opposition to them at the time. When flexion of the knee is resisted by quadriceps, the hamstring muscles produce extension at the hip. When extension of the hip is resisted by the hip flexors, the hamstring muscles produce flexion of the knee.

In addition, the hamstring muscles, acting separately, produce medial rotation and lateral rotation at the knee joint. As we’ve seen, these movements can only happen when the knee is flexed. The two semi-muscles produce medial rotation, biceps femoris produce lateral rotation.

The other two minor knee flexors that we’ve seen already are sartorius, and gracilis. Here’s sartorius, which arises up here. Here’s gracilis, arising here. These two insert close to semitendinosus. sartorius here, gracilis here.

We’ve already seen the actions of these two muscles at the hip. At the knee, they help to produce flexion. Now we’ll complete our picture of the muscles around the
knee by looking at three muscles at the back that we haven’t met yet, popliteus, gastrocnemius and plantaris.

Here’s the popliteus muscle. It arises from this area on the back of the tibia, and inserts up here on the lateral epicondyle of the femur. The tendon of popliteus passes through the capsule of the knee joint to reach its insertion. Popliteus is a minor flexor of the knee, and it can also produce medial rotation of the tibia.

Lying on top of popliteus is the small plantaris muscle. It’s a vestigial structure. It arises from the lateral epicondyle of the femur. The tiny tendon of plantaris runs down on the back of this big muscle, soleus. We’ll see where it ends up in the next section.

Lying on top of the two small muscles that we’ve just seen, is the much larger gastrocnemius muscle. Gastrocnemius arises by two heads, from the back of the medial and lateral condyles of the femur.

Gastrocnemius runs downward, and joins with the underlying soleus muscle, which we’ll see in the next section, to form the calcaneal tendon, or heel cord. Gastrocnemius has a slight flexing action at the knee, but its main action, by far, is at the ankle joint: we’ll see it again in the next section.

Now that we’ve seen all the muscles that arise or insert at the knee joint, let’s see how they all fit together.

**REVIEW**

You can use this overview as a brief review section.

Here on the front are quadriceps, sartorius, and gracilis. On the back, here are semitendinosus, and semimembranosus. Here’s biceps femoris. and here’s gastrocnemius, Here’s plantaris, and popliteus.

**VESSELS**

Now we’ll move on, to look at the principal veins, arteries and nerves in the region of the knee. We’ll begin where we saw them last, just below the hip. We’ll follow them to just below the knee.

With the main artery and vein, there’s a change of name that we need to understand. In the upper and middle thigh, they’re known as the femoral vessels, but below the adductor hiatus they’re called the popliteal vessels. The same vessels, just a different name.

Here’s the thigh, with the skin removed, and a strip of subcutaneous fat taken out so that we can see the long saphenous vein. Here it’s in the middle of its course from the ankle to the top of the thigh. To see the femoral vessels we’ll remove the superficial fat, and deep fascia.
Here are the femoral artery and vein at the point where we saw them last, disappearing beneath the sartorius muscle. To follow their course, we’ll remove sartorius, and also gracilis.

*Here’s vastus medialis, here’s adductor longus, with adductor magnus behind it. The femoral vessels pass beneath the roof of the adductor canal, and through the adductor hiatus. To see where they emerge, we’ll remove semi-membranosus and semi-tendinosus, and go round to the back. Here are the vessels emerging behind adductor magnus. They’re now known as the popliteal artery and vein.*

A little above the knee the popliteal vessels are joined by the sciatic nerve. At the back of the knee, the popliteal artery lies deep to the nerve, and to the popliteal vein. To see the artery better, we’ll go to a different dissection in which the muscles are intact, and the nerve and the vein have been removed.

Above the knee, which is just here, the popliteal artery gives off these two superior genicular arteries, lateral, and medial. At the knee it gives off these branches, to the two heads of gastrocnemius; and below the knee it gives off these two inferior genicular arteries, medial, and lateral. The popliteal artery then disappears deep to the two heads of gastrocnemius. We’ll see where the vessels go from there, in the next section.

**NERVES**

Now let’s look at the nerves. In the last section we looked at three major nerves - the obturator, the femoral, and the sciatic. We’ll follow the sciatic nerve in a minute. The obturator nerve and the femoral nerve we don’t need to follow any further, except to remind ourselves of the muscles that they supply.

As we’ve seen before, the obturator nerve supplies obturator externus, adductor brevis, and longus, and the anterior part of adductor magnus. The femoral nerve supplies iliacus, pectineus, all four heads of quadriceps, and sartorius.

The obturator and femoral nerves also have sensory branches, some of which go below the knee. We’ll leave these out. We’ll go on now to look at the sciatic nerve. We saw the sciatic nerve a minute ago, with the hamstring muscles absent. To see the whole picture, we’ll add the hamstring muscles.

Here are semimembranosus and semitendinosus, here’s biceps femoris. Here are the two heads of gastrocnemius. The space that’s bounded by these muscles is called the popliteal fossa. As we saw in the previous section, the sciatic nerve passes deep to biceps femoris. Here it is emerging. Here are the popliteal vessels, coming in beneath the "semi " muscles, and passing deep to the nerve. Above the knee the sciatic nerve divides into two major nerves - the tibial nerve, and the common peroneal nerve.

The tibial nerve runs downward in the midline, and passes between the two heads of gastrocnemius, along with the popliteal vessels. The common peroneal nerve, diverges laterally, running just behind the tendon of biceps femoris.

It passes around the neck of the fibula, here’s the fibula, and passes into this muscle, peroneus longus. We’ll follow the further course of both these nerves in the next section.
Of the muscles that we’ve seen in this section, the tibial nerve supplies popliteus, gastrocnemius, and plantaris.

We’ll conclude this section by briefly reviewing what we’ve seen of the vessels and nerves of this region.

REVIEW

Here’s the femoral vein, and artery; the superior genicular arteries, lateral, and medial and the inferior genicular arteries, medial and lateral. Here’s the popliteal artery, and vein.

Here’s the sciatic nerve, the tibial nerve, and the common peroneal nerve.

That brings us to the end of this section on the knee. In the next section we’ll look at the leg, the ankle, and the joints of inversion and eversion of the foot.

END OF PART 2
In this section we’ll go from the knee, to a little below the ankle. We’ll start by looking at the bones, and the joints of the the ankle region. Then we’ll look at the muscles which produce movements at those joints. Lastly we’ll look at the blood vessels and nerves of the region.

Before we start, we need to understand the meaning of some anatomic terms regarding the foot and its movements. The upper and lower surfaces of the foot are called the dorsal surface, and plantar surface. This part of the foot is called the tarsus, these bones are the tarsal bones. The long bones in front of them are the metatarsals.

We’ll be looking at two sets of movements, which happen in two different places. The upward and downward movements, that occur at the ankle joint itself, are called dorsi-flexion, and plantar flexion.

The side to side rocking movements that occur at the joints just below the ankle are called eversion, for turning outward, and inversion, for turning inward. Lastly, speaking of definitions, recall that “the leg” in anatomy means just the part of the lower extremity that's between the knee and the ankle.

Now lets look at the bones. We’ll start by taking a further look at the two long bones of the leg, the tibia and the fibula. The tibia is much the larger of the two bones.

The shafts of the two bones are covered by muscles, except for the anteromedial aspect of the tibia, which lies directly beneath the skin all the way from the knee to the ankle.. The proximal end of the fibula doesn’t form part of the knee joint, but its distal end forms an important part of the ankle joint, as we’ll see.

The tibia and fibula are held together throughout their length by the strong interosseous membrane. Above and below they’re attached at the two tibio-fibular joints. The proximal tibio-fibular joint is a synovial joint, the distal one is a fibrous joint. There’s very little movement at either of these joints. Distally the two bones are strongly held together by the anterior tibio-fibular ligament, and the posterior tibio-fibular ligament..

The projecting ends of the tibia and fibula, which stick out on either side of the ankle, are called the medial malleolus, and the lateral malleolus.

The articular surface for the ankle joint is a broad notch, formed by the curved undersurface of the tibia, and the inner surfaces of the medial malleolus, and the lateral malleolus.

Now let’s look at the bone that articulates with the tibia and fibula to form the ankle joint - the talus. This is the talus. The bone below and behind it is the calcaneus, or heel bone. The bone in front of the talus is the navicular bone. We’ll meet the remaining tarsal bones shortly. Now we'll go round to the lateral view to see the talus by itself.
This is the head of the talus, this is the neck. The talus has three articular surfaces, one on the head, and one on the underside for the two joints of inversion and eversion, and one on top for the ankle joint.

Here’s the ankle joint. Let’s see how it looks in the living body. Here the loose parts of the joint capsule have been removed, leaving these thickened parts, which are the ligaments of the joint. Here’s the front of the joint in plantar flexion, here’s the back of the joint in dorsiflexion.

On the lateral side, the joint is held together by the posterior talo-fibular and anterior talo-fibular ligaments. On the medial side it’s held together by this massive ligament, the deltoid ligament, which attaches not only to a broad area on the talus but also to the adjoining bones below and in front, as we’ll see shortly. The ligaments of the ankle joint ensure that the talus can’t rock from side to side like this, or move backward or forward like this, relative to the tibia and fibula.

Here’s the ankle joint with its joint capsule intact, and with the rest of the bones in place. The capsule of the ankle joint is loose on the front, and it’s also loose on the back. This looseness allows for a full range of dorsiflexion and plantar flexion.

Now we’ll move on, to look at the two joints of inversion and eversion. There’s one directly beneath the main part of the talus, called the subtalar joint; and there’s one below and in front of the head of the talus that has an unwieldy name, the talo-calcaneo-navicular joint. We’ll call it the T.C.N. joint for short.

To understand these joints we need to get acquainted with the remaining tarsal bones. We already know the talus, the calcaneus, and the navicular. In front of the navicular are the three cuneiform bones, first, second, and third. Lastly, the bone in front of the calcaneus is the cuboid bone.

Now let’s look at the calcaneus by itself. The posterior part of the calcaneus forms the heel. The massive calcaneal tendon, also called the Achilles tendon, is attached here. Here on the medial side there’s a projecting shelf which the medial part of the talus sits on, called the sustentaculum tali.

On the front of the calcaneus there’s an articular surface for the cuboid bone. On the upper aspect of the calcaneus there are two articular surfaces for the talus, a small one in front, a larger one behind.

The larger of these two surfaces, together with the corresponding surface on the underside of the talus, forms the subtalar joint. The head of the talus fits into a socket, which we’ll see by taking the talus away. The socket is formed by this surface of the calcaneus, this surface of the navicular bone, and by a strong ligament here which we’ll see in a minute. These surfaces, together with the head of the talus, form the talo-calcaneo-navicular joint.

Here’s what these joint surfaces look like in the living body: the surface for the subtalar joint, and the two surfaces for the T.C.N. joint. This structure in between, which forms part of the TCN joint, is the upper surface of the strong calcaneo-navicular ligament, also misleadingly called the spring ligament, which helps to hold up the head of the talus. It goes from here on the calcaneus to here on the navicular.

The movement that happens at the subtalar and T.C.N joints is a rocking motion, that takes place around an obliquely placed axis.
This rod shows the position of the axis: it’s oblique to the long axis of the foot both in this plane, and in this plane. Here’s eversion...here’s inversion. Again, eversion...and inversion

Several strong ligaments hold the malleoli, the talus, the calcaneus and the navicular bone together. On the medial side, which we’ll see first, there’s one extensive ligament to look at, the deltoid ligament. We’ve seen part of it already.

Now here’s the whole of the deltoid ligament. This is the part we saw before, going from from the medial malleolus to the talus. In addition, parts of the deltoid ligament fan out below onto the sustentaculum tali of the calcaneus, and in front onto the navicular bone, so that the deltoid ligament holds all four of these bones together.

On the lateral side there are two important ligaments, the calcaneo-fibular ligament which goes from the lateral malleolus to the side of the calcaneus, and this strong ligament, the interosseous talo-calcaneal ligament, which goes from here on the calcaneus, to here on the talus.

To see that ligament better, we’ll remove the talus. The interosseous talo-calcaneal ligament lies between the subtalar joint and the T.C.N. joint.

Now that we’ve seen the ankle joint and the joints of inversion and eversion, we’ll look very briefly at the remaining joints of the tarsus. Between the navicular and its neighbors, the cuneiform bones and the cuboid bone, there’s hardly any movement. But there is a small amount of rotation here between the cuboid and the calcaneus, which lets the front part of the foot invert and evert a little, independently of the calcaneus.

We’ll see more of the bones and ligaments of the foot in the next section. For now, we’ve seen enough to understand how the joints of the ankle region move. Before we move on to look at the muscles that produce those movements, we need to take a look at some important pulley-like structures that are attached to the bones of the ankle region. These are called retinacula, the singular of which is retinaculum. Each retinaculum guides and keeps in place a set of tendons that pass from the leg to the foot. There’s a retinaculum on the front of the ankle, and one on each side of the ankle, behind and below each malleolus.

Here on the front are the upper part and the lower part of the extensor retinaculum. These aren’t isolated structures, they’re localized thickenings of this layer of investing deep fascia, which we’ll meet later. Four tendons, a nerve and an artery pass under the extensor retinaculum.

On the lateral aspect, behind the malleolus, here’s the peroneal retinaculum. It accommodates the tendons of two peroneal muscles as they pass around the lateral malleolus.

On the medial side the flexor retinaculum fans out from the back of the medial malleolus. The space beneath the flexor retinaculum is divided into four separate tunnels. Three tendons, and the posterior tibial vessels and nerve, pass through these tunnels as they pass around the ankle and into the foot.

Now let’s review what we’ve seen of the bones, joints and pulleys of the ankle region. Then we’ll move on to look at the muscles of the leg.
REVIEW

Here’s the tibia, the fibula, the medial malleolus, the lateral malleolus, the talus, and the ankle joint.

Here’s the interosseous membrane, the proximal tibio-fibular joint, the distal tibio-fibular joint, the posterior tibio-fibular, and talo-fibular ligaments, the anterior tibio-fibular, and talofibular ligaments, and the deltoid ligament. Here’s the calcaneus, the cuboid, the three cuneiform bones, and the navicular.

Here are the surfaces for the subtalar joint, and for the T.C.N. joint. Here’s the calcaneo-navicular ligament, the calcaneo-fibular ligament, and the interosseous talo-calcaneal ligament. Here’s the extensor retinaculum, the peroneal retinaculum, and the flexor retinaculum.

MUSCLES

Now we’ll move on to look at the muscles that produce movement at the joints of the ankle region. In doing this, we’ll meet most but not all of the muscles that are in the leg.

There are four muscles that in the leg, the long flexors and extensors of the toes, that we’ll leave out of the picture till the next section. These are the long flexors and the long extensors of the toes. Along with the muscles, we’ll meet the various layers and partitions of deep fascia which divide the muscles of the leg into rather distinct compartments.

We’ll start with the muscles that produce dorsiflexion and plantar flexion at the ankle joint; next we’ll look at the fascial layers and compartments, lastly we’ll look at the muscles of inversion and eversion.

First, then, the dorsiflexors and plantar flexors. Dorsiflexion involves just lifting the foot. Plantar flexion involves lifting the whole body. So it’s not surprising that the muscles for plantar flexion are much larger than the ones for dorsiflexion.

There’s one muscle on the front of the leg for dorsiflexion, tibialis anterior. There are three on the back of the leg for plantar flexion, gastrocnemius, soleus, and plantaris. Here’s tibialis anterior. Tibialis anterior arises from the lateral surface of the upper tibia, and from the interosseous membrane.

The tendon of tibialis anterior passes under the extensor retinacula, and winds around the medial side of the tarsus, to insert right down here, on the first cuneiform bone, and on the base of the first metatarsal. The main action of tibialis anterior is to produce dorsiflexion at the ankle.

Dorsiflexion is not the only action of tibialis anterior. It also has a role in producing inversion, as we’ll see shortly. What’s more, tibialis anterior is not the only muscle that produces dorsiflexion. It’s assisted in that, by the long extensor muscles for the toes, which we’ll see in the next section.
We’ll move on now to look at the muscles that produce plantar flexion. Two large muscles, gastrocnemius and soleus, and one small muscle, plantaris, join together to form the massive calcaneal tendon.

Here’s gastrocnemius; here deep to it is soleus. Gastrocnemius has two heads, a medial and a lateral. These arise, as we’ve seen, from the medial and lateral condyles of the femur. The two heads of gastrocnemius unite, forming a flat tendon. The gastrocnemius tendon in turn unites with the tendon of soleus to form the calcaneal tendon. To look at soleus we’ll remove gastrocnemius.

Here’s the whole of soleus. Here’s its medial border, here’s its lateral border. Here’s the cut edge of the gastrocnemius tendon. Soleus arises from the medial edge of the tibia, from this oblique line on the back of the tibia, and from this area on the back of the fibula.

Between the fibular, and the tibial origins of soleus there’s an arch of fibrous tissue. The popliteal vessels, and the tibial nerve, pass beneath this arch. Here are their divided ends.

For completeness, we’ll add plantaris to the picture. Here it is. Plantaris arises here on the lateral epicondyle of the femur. The long tendon of plantaris runs almost to the ankle before uniting with the calcaneal tendon. The calcaneal tendon is also known as the Achilles tendon or simply the heel cord. It inserts into a broad area here, on the back of the calcaneus. In front of the calcaneal tendon there’s a pad of fat, which fills the gap between the tendon and the back of the ankle joint.

The action of soleus, gastrocnemius, and plantaris is to produce plantar flexion at the ankle joint. Their action lifts us off the ground when we stand on tip-toe. When balanced against gravity, the same action controls our rate of descent. In addition, these muscles provide an important part of the propulsive force in normal walking, in going uphill, in running, and in jumping.

Before we move on to see the muscles that produce inversion and eversion, we need to digress for two minutes, to look at the layer of deep fascia that surrounds all the muscles of the leg, and the three fibrous partitions, or septa that divide the leg muscles into somewhat distinct compartments.

This outer layer is the investing deep fascia. It surrounds all the muscles of the leg. The investing deep fascia is attached to the tibia here, and here. It’s attached to the fibula not directly, but indirectly by two fibrous septa here, and here, that we’ll see in a minute.

The investing deep fascia wraps around the back of the calcaneal tendon, like a sling. Distally the investing deep fascia is continuous with the superficial part of the flexor retinaculum, with the peroneal retinaculum, and with the two parts of the extensor retinaculum.

Now we’ll look at the fibrous septa, the singular of which is septum. There are three of them. Together with the interosseous membrane, they divide the muscles of the leg into four compartments, two on the front of the leg, and two on the back. We’ll look at the back first. We’ll remove gastrocnemius and soleus, down to here.
Here’s soleus, divided, here’s the investing deep fascia, divided at a lower level. In front of soleus, this transverse intermuscular septum crosses the back of the leg. It runs from here on the tibia, to here on the fibula.

Three muscles that we haven’t seen yet lie between the transverse septum and the bones. To see the transverse septum better, we’ll remove the rest of soleus. The transverse septum is thin up here, but toward the ankle it becomes thicker. At the ankle, the transverse septum is continuous with the flexor retinaculum.

The other two septa have cumbersome names: they’re the anterior and the posterior crural intermuscular septa. To see them, we’ll remove the investing deep fascia down to here, exposing several muscles that we haven’t met yet. We’ll be meeting them soon. This is the posterior crural septum, lying just in front of the soleus muscle. This is the anterior crural septum. These two septa are attached to the fibula here, and here.

The anterior crural septum divides the muscles in front of and lateral to the two bones into an anterior compartment, which contains four muscles including tibialis anterior, and a more laterally placed peroneal compartment, which contains two of the three peroneal muscles.

Now that we’ve seen these fascial structures, let’s get back to the muscles, the ones that produce inversion and eversion. There are two muscles that produce inversion, tibialis anterior, which we’ve seen already, and tibialis posterior.

Here’s tibialis posterior. Tibialis posterior arises from the back of the tibia, the back of the fibula, and from the interosseous membrane in between. Its tendon passes immediately behind the medial malleolus, through a fibrous tunnel that’s covered by the flexor retinaculum. Beyond the malleolus the tendon of tibialis posterior fans out. It has a wide insertion, here, on the navicular and first cuneiform bones and also under here, on the bases of the second, third and fourth metatarsals. Here’s the action of tibialis posterior: it inverts the foot.

The other muscle that can act as a foot invertor is tibialis anterior, which inserts so close to tibialis posterior that it has almost the same line of action. We looked at tibialis anterior, in its role as an ankle dorsiflexor, earlier in this section.

Now we’ll look at the three muscles that evert the ankle: peroneus longus, brevis, and tertius. Here’s peroneus brevis. Peroneus brevis arises from here on the distal fibula.

Lying on top of peroneus brevis, is peroneus longus. Peroneus longus arises from here on the proximal fibula. Its origin extends up onto the head of the fibula, with a gap here.

The deep peroneal nerve passes under the upper end of peroneus longus here, as we’ll see. The other muscle in the picture here is tibialis anterior.

At the ankle, the tendons of peroneus longus and brevis pass behind the lateral malleolus and beneath the peroneal retinaculum, longus behind, brevis in front. Peroneus brevis runs forward to insert here, on the base of the fifth metatarsal. To see the remarkable course of the peroneus longus tendon, we have to remove the entire sole of the foot. Peroneus longus runs around the cuboid bone, and along a deeply placed fibrous tunnel, to insert right over here, on the base of the first metatarsal.
Lastly, in front of peroneus brevis and longus, here’s peroneus tertius. Peroneus tertius arises from here on the fibula. The tendon of peroneus tertius passes under the extensor retinaculum, and in front of the lateral malleolus to insert here, on the base of the fifth metatarsal, next to peroneus brevis. The action of all three of the peroneal muscles is to evert the foot.

In addition, peroneus tertius, acting along with its anterior neighbors, can help to dorsiflex the ankle. The muscles of inversion and eversion are important, because they enable us to stay balanced and upright on a surface that tilts to one side, or to the other.

Now that we’ve looked at the muscles that produce movement of the foot, we’re nearly ready to move on to the vessels and nerves of this region. Before we do that, let’s review what we’ve seen of the muscles, and the associated fascial structures.

**REVIEW**

Here’s the investing deep fascia, here’s the posterior crural septum, the anterior crural septum, and the transverse intermuscular septum. Here’s tibialis anterior, here’s gastrocnemius, soleus, and plantaris, and the calcaneal tendon. Here’s tibialis posterior, peroneus longus, peroneus brevis, and peroneus tertius.

**VESSELS**

Now we’ll move on, to look at the vessels and nerves of the region. We’ll go from the knee, where we saw them last, to just below the ankle. We’ll start with the veins.

Here’s the leg with the skin removed. To expose the two major superficial veins, two strips of subcutaneous fat have also been removed. Here’s the short saphenous vein on the back, and the long saphenous vein on the front.

The long saphenous vein passes over the medial malleolus, which is here and runs up the medial side of the leg. We’ve seen its more proximal course in the previous sections of this tape.

The short saphenous vein runs up between the calcaneal tendon and the lateral malleolus. It goes up the back of the leg, and passes through the deep fascia near the knee to join the popliteal vein.

To see some of the superficial veins in more detail, we’ll remove the subcutaneous fat from the back of the leg. The short saphenous vein, like the long saphenous vein, is joined by a number of superficial branches. The saphenous veins are also joined by several perforating veins like this one, which bring blood from the muscle compartments that lie deep to the investing deep fascia.

In the last section we saw the principal deep vein of the leg, the popliteal vein. Here it is again. With the tibial nerve behind it and the popliteal artery in front of
it, it disappears between the two heads of gastrocnemius. In this section we won’t follow the deep veins any further, since their course is just the same as that of the corresponding arteries.

We’ll look at the arteries next. The three main arteries which supply the leg and ankle region are all branches of the popliteal artery. They’re the anterior tibial, the posterior tibial, and the peroneal. In the dissection that we’ll see, all the veins have been removed, to simplify the picture.

Here’s the popliteal artery, passing between the two heads of gastrocnemius. Its branches to gastrocnemius have been removed. To follow the popliteal artery, we’ll remove gastrocnemius. The popliteal artery runs down the back of the popliteus muscle, then passes through the fibrous arch in the origin of soleus. We’ll remove soleus.

At the lower border of the popliteus muscle, the popliteal artery gives off this major branch, the anterior tibial artery, which runs forwards. We’ll follow it in a minute. The popliteal artery then ends by dividing into the peroneal artery, and the posterior tibial artery. We’ll follow the posterior tibial artery first. It runs down the back of the leg, just behind the deep posterior muscles. It’s covered by the increasingly thick transverse intermuscular septum, which we’ll remove.

As it passes toward the medial side of the ankle, the posterior tibial artery lies just behind tibialis posterior. At the ankle, the artery passes through a tunnel beneath the flexor retinaculum, part of which has been removed here. Within its tunnel, the posterior tibial artery divides into the medial plantar, and lateral plantar arteries, which we’ll follow in the next section.

Next we’ll look at the peroneal artery. The peroneal artery passes laterally, and runs beneath a muscle that we’ll be looking at at in the next section, flexor hallucis longus. We’ll remove it. The peroneal artery runs down between the deep posterior muscles, close to the fibula, which is here. It gives off numerous branches to the surrounding muscles, and ends behind the lateral malleolus.

Lastly, we’ll look at the anterior tibial artery. Here’s where we saw the anterior tibial artery last, arising from the popliteal artery. It immediately passes forward through a gap in the interosseous membrane. We’ll go round to the front to follow it. Here it is emerging. The anterior tibial artery runs down the leg on the interosseous membrane, just lateral to tibialis anterior. The long toe extensors, which have been removed in this dissection, lie lateral to the artery. At the ankle, the anterior tibial artery passes beneath the extensor retinaculum. Here’s the artery emerging on the dorsum of the foot. Beyond this point it’s called the dorsalis pedis artery. We’ll follow it further in the next section.

NERVES

Now we’ll look at the nerves of this region, the tibial nerve, and the common peroneal nerve. We saw them last at the knee, the tibial nerve disappearing, along with the popliteal vessels, between the heads of gastrocnemius; the common peroneal nerve disappearing underneath peroneus longus. We’ll look at the tibial nerve first. To follow it, we’ll remove two muscles which it supplies: gastrocnemius, and soleus.
The tibial nerve follows the same course as the posterior tibial artery. The nerve passes beneath the flexor retinaculum just behind the artery. Beneath the flexor retinaculum, the tibial nerve divides, into the medial plantar nerve, and the lateral plantar nerve. We’ll see where these go in the next section.

In the leg, the tibial nerve supplies gastrocnemius, plantaris, soleus, and all three of the deep flexor muscles, including tibialis posterior.

Now we’ll follow the common peroneal nerve. As it passes under the peroneus longus muscle, the common peroneal nerve divides, into the superficial peroneal nerve, and the deep peroneal nerve. The superficial peroneal nerve runs down beneath peroneus longus. It emerges here, and continues down to the foot as a sensory nerve, as we’ll see in the next section. The superficial peroneal nerve supplies peroneus longus, and peroneus brevis.

The deep peroneal nerve runs under peroneus longus, here it is again, and then under this adjoining muscle, which is extensor digitorum longus. Here’s the deep peroneal nerve emerging, just medial to the anterior tibial vessels, and medial to tibialis anterior. The deep peroneal nerve follows the same course as the anterior tibial vessels, as it runs down the leg, and under the extensor retinaculum.

Of the muscles that we’ve already seen in the leg, the deep peroneal nerve supplies: tibialis anterior, and peroneus tertius.

Now let’s review what we’ve seen of the vessels and nerves of the leg and ankle region.

REVIEW

Here’s the long sapheous vein, the short saphenous vein, and the popliteal vein. Here’s the popliteal artery, the peroneal artery, and the posterior tibial artery, the medial plantar, and lateral plantar arteries, and the anterior tibial artery.

Now the nerves: the tibial nerve, the medial plantar nerve, and the lateral plantar nerve, the common peroneal, superficial peroneal, and deep peroneal nerves.

That brings us to the end of this section on the leg and ankle. In the next section, we’ll look at the foot.

END OF PART 3
PART 4: THE FOOT

BONES, LIGAMENTS AND JOINTS

In this section we’ll look at the foot. As usual, we’ll start with the bones. After that we’ll look at the joints and ligaments, the muscles, the blood vessels and nerves, and lastly the skin.

We saw most of the bones of the foot in the last section. Here, we'll briefly review the tarsal bones, then we'll look at the metatarsals and the bones of the toes.

Here’s the calcaneus, the talus, the navicular, the cuneiforms - first, second, and third -, and the cuboid. Let’s see the same bones again from beneath: the calcaneus, the cuboid, the cuneiforms, the navicular, and the talus again.

Now we’ll look at the metatarsals. Like the toes, the metatarsals are numbered one, through five. The first metatarsal is more massive than the others. The second metatarsal is the longest. On the base of the fifth metatarsal there’s a prominent tubercle.

The metatarsals are slightly curved from end to end. The heads of the metatarsals lie in one flat plane, but their bases form an arch from side to side, as do the tarsal bones that they articulate with. These are the three cuneiform bones, and the cuboid. These are the tarsometatarsal joints. There’s very little movement at any of them.

The bones of the foot are arched in two planes, from side to side as we’ve just seen, and also from end to end. We’ll be looking at the structures that support the arches of the foot in a minute. To finish with the dry bones, let’s look at the toes.

The big toe has only two phalanges, a proximal, and a distal. The other four toes have three phalanges, proximal, middle, and distal. These are the metatarso-phalangeal joints, or MP joints for short. The joints between the phalanges are the interphalangeal joints.

The bones of the toes are quite similar to the corresponding bones of the fingers, which are shown in Volume 1 of this atlas. Now that we’ve seen the dry bones of the foot, let’s see what they’re like in the living body. We’re already familiar with the ligaments around the ankle. What we’ll look at now are the ligamentous structures that hold this apparently delicate arch of bones together, and enable it to support the whole weight of the body.

Here’s the foot with all the soft tissues removed, and all the joints and ligaments intact. On the dorsum of the foot there’s an almost continuous layer of ligaments, connecting the tarsal bones both to each another and to the metatarsals, and connecting the heads of the metatarsals together. The ligaments on the dorsum of the foot are strong ligaments, but the truly impressive ligaments, the ones which support the longitudinal arch, are on the underside of the foot.
First, here's the short plantar ligament. It goes from here on the calcaneus, to here on the cuboid bone. Just in front of the short plantar ligament is the groove for the peroneus longus tendon. Lying directly beneath the short plantar ligament is the long plantar ligament. The long plantar ligament also starts here on the calcaneus, and goes all the way to the bases of the third, fourth and fifth metatarsals.

The long plantar ligament bridges over, or rather under, the peroneus longus tendon - here's the tendon, going to its insertion on the base of the first metatarsal.

There's another, even more impressive structure that supports the arch of the foot - the plantar aponeurosis. The plantar aponeurosis is a massive sheet of tendon-like tissue that runs the whole length of the foot. It starts here on the calcaneus. It fans out as it runs forward. As it approaches the MP joints, the plantar aponeurosis splits into five divisions. Most of the fibers of each division pass into two slips, which pass forward and upward toward the M.P. joint. We'll see where they go in a minute.

To understand where the slips of the plantar aponeurosis insert, we first need to look at the MP joints, and at some structures nearby: the flexor tendon sheaths, the plantar ligaments of the MP joints, and the ligament that connects the metatarsal heads, the deep transverse metatarsal ligament.

Here's the deep transverse metatarsal ligament. It goes all the way from the first MP joint, to the fifth. The flexor tendon sheaths, which we'll see in a minute, are attached along these lines.

To take a look at a typical MP joint, and the structures around it, we'll look at a toe and its metatarsal in isolation. Here's the MP joint with its capsule intact. Here it is with the loose parts of the capsule removed. There's a broad collateral ligament on each side. The MP joint can't flex much beyond a straight position, but it can extend all the way to here.

Here's an MP joint divided longitudinally. The joint capsule is thin on the dorsal aspect, and massively thickened on the plantar aspect. This thick part of the capsule is the plantar ligament of the MP joint, it's fixed to the proximal phalanx here, so when the joint is extended, the plantar ligament is pulled forward.

Here's the plantar ligament in the intact joint. The tendon sheath is attached to the plantar ligament here, and here. Here's a short piece of the tendon sheath intact. It runs the whole length of the toe, as we'll see later. Also attached to the plantar ligament of the MP joint is the deep transverse metatarsal ligament: here's its attachment on one side, here it is on the other side.

Here's the MP joint of the big toe, the first MP joint. It's much larger than the other MP joints, and it has two additional structures, a pair of sesamoid bones, which are enclosed within the plantar ligament. One of them's here, the other one's here.

Now that we've looked at the MP joints and the structures around them, let's go back to the plantar aponeurosis, and see how it's inserted. As we've
seen, each division of the aponeurosis gives rise to two slips. These lie on each side of the flexor tendons. The two slips are inserted here, and here, on each side of the plantar ligament of the MP joint.

Since the plantar aponeurosis is inserted into a set of movable structures, the plantar ligaments of the MP joints, its tightness varies depending on the position of these joints. When the MP joints are straight, the plantar aponeurosis is slack, but when they’re extended, it becomes much tighter.

The plantar aponeurosis acts as a continuation of the achilles tendon. When it’s tight, as it is when the MP joints are extended, it enables the pull of the calcaneal tendon be transmitted directly to the metatarsal heads. That’s why the arch of the foot remains an arch, even at the moments when we place the heaviest loads on it.

The plantar aponeurosis is the central part, and much the strongest part, of a layer of fascia, the plantar fascia, which covers the entire sole of the foot. We’ll see the whole of the plantar fascia when we've looked at at the muscles of the foot, which we’re going to do shortly. Let’s now review what we’ve seen, of the bones, joints, and ligaments of the foot.

**REVIEW**

Here are the metacarpals, the proximal phalanges, the middle phalanges, and distal phalanges, the tarso-metatarsal joints, the metatarso-phalangeal joints, and the interphalangeal joints.

Here are the short plantar ligament, the long plantar ligament, and the plantar aponeurosis. Here’s the deep transverse metatarsal ligament, the flexor tendon sheaths, and the plantar ligament of the MP joint.

**MUSCLES**

Now we’ll look at the muscles which produce movement of the toes. We’ll look at the extensor muscles first. There are two long extensors to the toes, and two short ones. The long extensors are two of the four muscles that we left out of the picture in the last section.

Here’s extensor hallucis longus. Extensor hallucis longus arises from the interosseous membrane, and from the adjoining fibula. Lying on top of extensor hallucis longus is extensor digitorum longus. Extensor digitorum longus has a long line of origin here on the fibula. This gap is for the common peroneal nerve.

To see all the muscles of the anterior compartment together, we’ll add tibialis anterior to the picture, here it is. We saw tibialis anterior in the last section. It almost covers up extensor hallucis longus. We’ll also add peroneus tertius, which arises in continuity with extensor digitorum longus.

Here are the tendons of all these muscles passing under the extensor retinaculum: peroneus tertius, extensor digitorum longus, extensor hallucis longus, and tibialis anterior.
The tendon of extensor hallucis longus inserts partly into the extensor expansion of the first MP joint, and partly here, into the base of the distal phalanx of the big toe.

The tendons of extensor digitorum longus insert, by way of the extensor expansion of each toe, into the bases of the middle and distal phalanges. The extensor expansion of the toe is quite similar to the extensor expansion of the finger, which is described in some detail in Volume 1 of this atlas. Here's the action of extensor hallucis longus: it extends both joints of the the big toe. Here's the action of extensor digitorum longus: its action is mainly at the MP joint.

The two long toe extensor muscles have another important action besides extending the toes. They’re also quite powerful dorsiflexors of the ankle.

Now let’s add the short extensors to the picture. Here they are. They lie beneath the tendons of the long extensors. Extensor hallucis brevis goes to the big toe, the four slips of extensor digitorum brevis go to the four short toes. The short toe extensors arise here, on the front of the calcaneus.

The tendons of the short extensors join the corresponding long extensor tendons. The action of the short extensors is the same as that of the long extensors, except that they don’t dorsiflex the ankle.

Now we’ll look at the muscles which flex the toes. First we’ll look at the two long flexors, flexor hallucis longus, and flexor digitorum longus. They’re the other two muscles that we left out of the picture in the last section.

Here’s flexor hallucis longus. Flexor hallucis longus arises from here on the back of the fibula. Medial to flexor hallucis longus is flexor digitorum longus. Flexor digitorum longus arises from here on the back of the tibia. This gap is for the tendon of tibialis posterior.

The relative position of these two muscles, this one for the big toe,  this one for the four small toes, is the reverse of what you’d expect when you look at where they’re going. As we’ll see, their two tendons cross over just below the ankle.

To complete our picture of the deep posterior leg muscles, we’ll add the third one, tibialis posterior to the picture. We saw it in the last section. It’s the most deeply placed of the three muscles. Tibialis posterior, crosses beneath flexor digitorum longus, and emerges in front of it, just above the ankle.

At the ankle, here are flexor hallucis longus, flexor digitorum longus, and tibialis posterior, each passing beneath the flexor retinaculum in its own fibrous tunnel. Emerging below the retinaculum, the two long toe flexors cross over, flexor hallucis longus lying deeper.

The tendon of flexor hallucis longus passes forwards, and enters the fibrous flexor tendon sheath of the big toe. The two sesamoid bones lie on each side of it, here and here, as it passes beneath the MP joint. Flexor hallucis longus is inserted here, on the base of the distal phalanx of the big toe. Flexor digitorum longus divides into four tendons, one for each of the small toes. These pass along the flexor tendon sheaths, and insert here on the
distal phalanges. Here’s the action of flexor hallucis longus, here’s the action of flexor digitorum longus.

Now we’ll move on, to look at the numerous small muscles on the plantar aspect of the foot. The intricacy of these muscles reminds us that our human foot has evolved from feet that had many other functions besides that of being walked on. Since some of the smaller muscles are now almost vestigial structures, we’ll be looking at them quite briefly.

We’ll look at the small plantar muscles in four groups, first the interosseous muscles; then the short muscles that occupy the middle of the foot; then the short muscles for the big toe; and lastly the ones for the fifth toe.

Here are the interosseous muscles. There are seven of them, two for each of the three middle toes, and one for the fifth toe. The interosseous muscles arise from the shafts of the metatarsals, and insert into the bases of the proximal phalanges. The action of the interosseous muscles is to flex the toes at the MP joints.

Now we’ll look at the middle group of muscles. These are all closely associated with the tendon of flexor digitorum longus. The middle group consists of the tiny lumbral muscles, flexor accessorius, and, superficial to them, flexor digitorum brevis, which we’ll see again in a moment. The four lumbral muscles are just like the lumbral muscles in the hand. We won’t look at them in detail.

Flexor accessorius, also called quadratus plantae, arises by two heads from here and here on the calcaneus. Flexor accessorius inserts here, into the deep aspect of the tendon of flexor digitorum longus. Flexor accessorius aids in flexing the toes.

Now we’ll add flexor digitorum brevis to the picture - here it is again. Flexor digitorum brevis arises from here on the calcaneus. Flexor digitorum brevis divides to form four tendons. Each of these enters one of the tendon sheaths, along with a tendon of flexor digitorum longus. Inside the tendon sheath, which we’ll remove, the brevis tendon splits into two halves, which encircle the longus tendon. Flexor digitorum brevis inserts here, on the bases of the middle phalanges. Flexor digitorum brevis assists in producing flexion at the PIP and MP joints. Lying superficial to flexor digitorum brevis is the plantar aponeurosis, which we’ve looked at already.

Now we’ll look at the muscles for the big toe. To build up a picture of them, we’ll first take the middle group of muscles out of the picture so that we’re again looking at just the interossei. The muscles for the big toe are flexor hallucis brevis, adductor hallucis, and abductor hallucis. We’ll look at them in that order.

Flexor hallucis brevis has two almost distinct parts, which arise here from the cuboid and third cuneiform bones. Flexor hallucis brevis gives rise to two tendons of insertion, which attach first to the medial and lateral sesamoid bones, then to the base of the proximal phalanx of the big toe. The tendon of flexor hallucis longus - which we’ll add to the picture for a moment - runs between the two halves of flexor hallucis brevis.
Here’s adductor hallucis. It arises by two heads, an oblique head, and a transverse head. The oblique head arises from the bases of the middle three metatarsals, the transverse head arises from the deep transverse metatarsal ligament.

These two heads converge, and merge with the medial head of flexor hallucis brevis, sharing its insertion on the medial sesamoid bone, and on the base of the proximal phalanx.

Medial to flexor hallucis brevis is abductor hallucis. Abductor hallucis is the most medial of all the foot muscles. It arises here, on the medial side of the calcaneus. The tendon of abductor hallucis merges with the medial part of flexor hallucis brevis, and inserts with it here, on the medial sesamoid bone, and on the base of the proximal phalanx.

The main action of all three of the short muscles of the big toe is to produce flexion at the MP joint. In addition, adductor and abductor hallucis brevis can produce adduction and abduction of the big toe.

Lastly, there are two short muscles for the fifth toe, a short flexor and an abductor. Here’s the flexor, flexor digiti minimi brevis. It’s an outlying interosseous muscle that’s been given a long name. Here’s the abductor, abductor digiti minimi. It arises all the way back here, on the calcaneus. It’s inserted here, on the proximal phalanx of the fifth toe.

Now that we’ve seen the muscles for the big toe and the fifth toe, we need to see how all these short muscles fit together. To do that, we’ll put the long flexor tendons, and then the central group of muscles back into the picture.

First we’ll add flexor hallucis longus to the picture. Flexor hallucis longus lies deep to abductor hallucis as it enters the foot. Here’s flexor digitorum longus, entering the foot along with flexor hallucis longus. The tendons of flexor digitorum longus cover up adductor hallucis. Here are the lumbricals, flexor accessorius, and last of all flexor digitorum brevis.

Now that we’ve seen all the muscles of the foot, let’s get a complete picture of the layer of deep fascia that encloses them all, the plantar fascia.

The central, thickened part of the plantar fascia is the plantar aponeurosis, which we’ve seen already. The medial and lateral parts of the plantar fascia extend on each side of the plantar aponeurosis. On the medial side the plantar fascia covers abductor hallucis.

On the lateral side it covers abductor digiti minimi. Here on the lateral side there’s a marked thickening of the plantar fascia, called the lateral cord of the plantar aponeurosis, which goes from here on the calcaneus, to here on the base of the fifth metatarsal. The lateral cord of the plantar aponeurosis helps to support the longitudinal arch of the foot, on the lateral side.

We’ve seen all the muscles of the foot! Let’s review them, before we move on to look at the blood vessels and nerves of the foot.
REVIEW

Here’s extensor digitorum longus, extensor hallucis longus, extensor digitorum brevis, and hallucis brevis. On the back, here’s flexor digitorum longus, flexor hallucis longus,

Here are the interosseous muscles, the lumbricals, flexor accessorius, and flexor digitorum brevis. Here’s abductor hallucis, flexor hallucis brevis, and adductor hallucis; and lastly here are abductor digiti minimi and flexor digiti minimi brevis

VESSELS

Now we’ll look at the blood vessels and nerves of the foot, starting with the veins. The superficial veins of the lateral aspect of the foot join together to form the short saphenous vein. The ones on the medial aspect of the foot join together to form the long saphenous vein.

In addition, at a deeper level, the arteries, which we’ll be looking at next, are closely accompanied by concomitant veins, like these. From here on we’ll remove all the concomitant veins to simplify the picture.

We last saw the anterior, and posterior tibial arteries entering the foot, beneath the extensor retinaculum and flexor retinaculum respectively. Here’s the anterior tibial artery at the ankle, passing beneath the extensor retinaculum. We’ll remove the retinaculum.

As it passes in front of the ankle, the anterior tibial artery crosses beneath extensor hallucis longus, emerging lateral to it. It gives off branches to the tarsal region, then continues on to the dorsum of the foot. Beyond this point it’s known as the dorsalis pedis artery.

The dorsalis pedis artery passes beneath the extensor hallucis brevis muscle, gives off this first dorsal metatarsal artery, and ends by diving through the first interosseous muscle to join up with the lateral plantar artery which we’ll see in a minute.

Now we’ll look at the posterior tibial artery, or rather, at its two terminal branches, the medial plantar, and lateral plantar arteries. Here’s where we saw them last, emerging from under the flexor retinaculum, the lower part of which has been removed in this dissection. Also removed, are the abductor hallucis muscle, here, and the plantar aponeurosis, here. This is the distal end of the posterior tibial artery. This is the the lateral plantar artery, this is the medial plantar artery.

The medial plantar artery is usually the smaller of the two. It crosses over the tendons of the two long toe flexors, and runs along the medial side of the foot. Its branches supply the adjoining muscles, and the underside of the big toe.

Now we’ll look at the lateral plantar artery. It passes deep to flexor digitorum brevis, which we’ll remove. After giving off this calcaneal branch, the lateral plantar artery passes downwards and then laterally, across flexor accessorius. When it reaches the base of the fifth metatarsal, which is here,
it curves around and passes deep to flexor digitorum longus and the interosseous muscles, to join up with the dorsalis pedis artery.

NERVES

Now we’ll look at the nerves of the foot. We’ll follow the nerves that we saw in the last section: the superficial and deep peroneal nerves, and the medial and lateral plantar nerves. There are two more nerves that we’ll also look at for completeness - the sural nerve, and the saphenous nerve. We’ll start with the two peroneal nerves.

The superficial peroneal nerve runs down in front of the lateral side of the ankle, and breaks up into several branches. These fan out to provide sensation to this large area on the dorsum of the foot.

The deep peroneal nerve enters the foot along with the dorsalis pedis artery. It gives off a motor branch, which supplies the short toe extensor muscles. It continues distally as a sensory nerve, which supplies this small area between the big and second toes.

Next we’ll look at the medial and lateral plantar nerves. They follow the same course as the medial and lateral plantar arteries. Here’s the medial plantar nerve. It gives off a motor branch which supplies flexor digitorum brevis, abductor hallucis, and flexor hallucis brevis.

To follow the medial plantar nerve, we’ll go round to the underside of the foot. Distally, the medial plantar nerve breaks up into common plantar digital nerves. These pass between the metatarsal heads, where each in turn divides into two plantar digital nerves.

The median plantar nerve supplies the underside of the big toe, the second, third and half of the fourth toes. It also supplies this medial area on the sole of the foot.

Now we’ll look at the lateral plantar nerve. It runs just in front of the lateral plantar artery. To follow it, we’ll again go round to the underside of the foot. Flexor digitorum brevis has been removed. The lateral plantar nerve gives motor branches to flexor accessorius and abductor digiti minimi.

It then divides into a deep branch, which supplies all the interossei and adductor hallucis, and a superficial branch, which supplies flexor digiti minimi brevis, and provides sensation to the lateral part of the sole, the fifth toe and half of the fourth toe.

To complete our picture of the nerves that provide sensation to the foot, we’ll add two nerves that were passed over in the last section - the sural nerve, and the saphenous nerve.

The sural nerve, which runs down the back of the leg, is formed by two nerves which join together. One is the medial sural cutaneous branch of the tibial nerve, the other is the sural communicating branch of the common peroneal nerve.
The sural nerve runs down the lateral side of the ankle, behind the lateral malleolus. The sural nerve supplies sensation to a variable area along the lateral side of the foot.

The saphenous nerve, a branch of the femoral nerve, emerges at the knee, from beneath the insertion of the sartorius muscle. It runs down the medial side of the leg, and supplies a variable area on the medial side of the foot and ankle.

Last of all, the heel area is supplied by calcaneal branches of the tibial nerve, which are given off beneath the flexor retinaculum. Now let’s review what we’ve seen of the blood vessels and nerves of the foot.

REVIEW

Here’s the start of the long saphenous vein, and the short saphenous vein. Here’s the dorsalis pedis artery, the lateral plantar artery, and the medial plantar artery,

Here’s the sural nerve, the superficial peroneal nerve, and the saphenous nerve, the deep peroneal nerve, the medial plantar nerve, and the lateral plantar nerve,

SKIN OF FOOT

Last of all, we’ll look at the skin of the foot. On the dorsum of the foot, the skin is thin and mobile. On the plantar aspect the skin is markedly thickened, especially in the weight bearing areas. There’s a generous padding of fat on the sole of the foot, especially on the heel.

The skin on the sole of the foot is tethered to the deeper tissues by numerous firm strands of fibrous tissue. These strands arise from the underlying bone, and plantar aponeurosis, and pass through the fat, into the subdermis, keeping the weight bearing skin firmly in place.

That brings us to the end of Volume 2. In Volume 3, we’ll look at the musculo-skeletal system of the trunk, from the neck, to the pelvis.

END OF VOLUME 2