The Knee Joint.

The knee joint is the largest joint in the human body, and is one of the most complicated. However, it is also one of the least stable joints, and is therefore prone to injury and osteoarthritic change. Movement involves flexion and extension, with a small degree of rotation, and the joint is considered to be ‘mobile’ due to movement of the menisci during motion.

Osteology.

The knee joint consists of three articulations in one: two condyloid joints, one between each condyle of the femur and the corresponding meniscus and condyle of the tibia; and a third between the patella and the femur. The joint is made up of four main bones- the femur, the tibia, the patella, and to a much lesser extent, the fibula. The surfaces of the articular areas are covered with articular cartilage to allow smooth movement and transmission of forces across the joint.

The articular bodies of the femur are its lateral and medial condyles, which are not directly in-line with each other but diverge slightly, the lateral condyle being wider anteriorly, whilst the medial condyle maintains a relatively constant width.
The tibial portion of the knee joint consists of the tibial plateau, separated into tibial condyles via the intercondylar eminence composed of a lateral and a medial tubercle.

The patella is inserted into the thin anterior wall of the joint capsule. On its posterior surface are lateral and a medial articular surfaces separated by a vertical ridge, which corresponds to the groove on the patella surface of the femur.
**Joint capsule.**

This is the articular capsule surrounding the joint, with an outer layer composed of avascular, white fibrous tissue, and an inner layer which is often known as the synovial membrane. The outer layer consists almost entirely of bands of fibrous tissues, but beneath the tendon of Quadriceps femoris and the patella it consists of synovial membrane only.

Anteriorly, the strength of the joint capsule comes directly from fibrous expansions from the fascia lata and iliotibial band, and from the vasti muscle group. This is referred to as the medial and lateral patella retinacula.

Posteriorly, the capsule consists of vertical fibres arising from the femoral condyles, and is situated around the cruciate ligaments, excluding them from the joint cavity. Posterior to the cruciate ligaments is the oblique popliteal ligament. Laterally, a prolongation from the iliotibial band fills in the interval between the oblique popliteal and the fibular collateral ligaments, and partly covers the latter. Medially, expansions from the Sartorius and Semimembranosus pass upward to the tibial collateral ligament to strengthen the capsule.
The synovial membrane follows the path of the joint capsule, but in addition also extends superiorly behind the tendon of Quadriceps femoris to form the supra-patella bursa. This pouch of synovial membrane is supported during movement by a small muscle, the Articularis genus, which pulls the synovial membrane out of the way and prevents it from interfering with patella movement.

Below the patella, the synovial membrane is separated from the ligamentum patellæ by a considerable quantity of fat, known as the infrapatellar pad. From the medial and lateral borders of the articular surface of the patella areas of the synovial membrane project into the interior of the joint, forming the alar folds, which eventually combine to form the patella fold.

On either side of the joint, the synovial membrane passes downward from the femur, lining the capsule to its point of attachment to the menisci. It may then be traced over the upper surfaces of these to their free borders, and thence along their under surfaces to the tibia. At the back part of the lateral meniscus it forms a small sac (the sub-popliteal recess) between the groove on its surface and the tendon of the Popliteus.
There are also a number of other, non-articular bursae around the knee, consisting of cavities lined with synovial membrane, and containing synovial fluid - the pre-patella bursa, and the deep and superficial infrapatella bursae.

**Extra-articular ligaments.**

**Patella ligament (patella tendon)** - This consists of the central portion of the tendon of Quadriceps femoris continuing from the patella down to the tuberosity of the tibia. It is a strong, flat, ligamentous band, about 8 cm long. Superiorly, it is attached to the apex and adjoining margins of the patella and the rough depression on its posterior surface, and inferiorly to the tuberosity of the tibia. Superficial fibres are continuous over the front of the patella with those of the tendon of the Quadriceps femoris. The medial and lateral portions of the tendon of the Quadriceps pass down on either side of the patella, to be inserted into the upper extremity of the tibia on either side of the tuberosity. All these fibres are attached to the joint capsule, forming the medial and lateral patellar retinacula. The posterior surface of the patella ligament is separated from the synovial
membrane of the joint by a large infrapatellar pad of fat, and from the tibia by a bursa - the deep infrapatella bursa.

**Tibial Collateral Ligament (medial collateral ligament)** - this is a broad, flat, membranous band, situated nearer to the back than to the front of the knee joint. It is attached superiorly to the medial condyle of the femur immediately below the adductor tubercle, and inferiorly to the medial condyle and medial surface of the body of the tibia. The fibres of the posterior part of the ligament are short and incline backward as they descend; they are inserted into the tibia above the groove for the Semimembranosus. The anterior part of the ligament is a flattened band, about 10 cm long, which inclines forward as it descends. It is inserted into the medial surface of the body of the tibia about 2.5 cm below the level of the condyle, and it adheres directly to the medial meniscus and joint capsule.

**Fibular Collateral Ligament (lateral collateral ligament)** - this is a strong, rounded, fibrous cord, attached to the back part of the lateral condyle of the femur, immediately above the groove for the tendon of the Popliteus, passing downwards to the lateral side of the head of the fibula, in front of the styloid process. The greater part of its lateral surface is covered by the tendon of the Biceps femoris. Deep to the ligament are the tendon of the Popliteus, and the inferior lateral genicular vessels and nerve. The ligament has no attachment to the lateral meniscus. Sometimes, there is an additional structure known as the short fibular collateral ligament, running parallel to the main ligament.
The Oblique Popliteal Ligament - this is a broad, flat, fibrous band, formed of fasciculi separated from one another by apertures for the passage of vessels and nerves. It is attached above to the upper margin of the intercondyloid fossa and posterior surface of the femur close to the articular margins of the condyles, and below to the posterior margin of the head of the tibia. Superficial to the main part of the ligament is a strong fasciculus,
derived from the tendon of the Semimembranosus and passing from the back part of the medial condyle of the tibia obliquely upwards and laterally to the back part of the lateral condyle of the femur. The oblique popliteal ligament forms part of the floor of the popliteal fossa, and the popliteal artery rests upon it.

Intracapsular structures

The cruciate ligaments situated in the middle of the knee joint, nearer to the posterior than anterior surface. They are called cruciate because they cross each, and the names ‘anterior’ and ‘posterior’ relate to their relative attachment positions on the tibia.

**Anterior Cruciate Ligament (ACL)** - attached to the depression in front of the intercondyloid eminence of the tibia. It passes upward, backward, and laterally, and is fixed into the medial and back part of the lateral condyle of the femur. Its role is to prevent forward displacement of the tibia when the femur is stabilised.

**Posterior Cruciate Ligament (PCL)** - is stronger, but shorter and less oblique in its direction than the ACL. It is attached to the posterior intercondyloid fossa of the tibia, and to the posterior extremity of the
lateral meniscus. It passes upward, forward, and medially, to be fixed into the lateral and front part of the medial condyle of the femur. Its role is to prevent posterior displacement of the tibia when the femur is stabilised.

Transverse Ligament - this connects the anterior convex margin of the lateral meniscus to the anterior end of the medial meniscus, its thickness varying in different subjects, and it is sometimes absent.

Coronary ligaments (meniscotibial ligaments) - extensions of the capsule, which connect the periphery of each meniscus with the margin of the head of the tibia, acting as anchorage.
Menisci

The menisci are two crescent-shaped pieces of fibrocartilage, which act to increase the congruency of the knee joint by deepening the articular cup of the tibia, and increasing stabilisation of the femoral condyles. The peripheral border of each meniscus is thick, convex, and attached to the inside of the capsule of the joint. The opposite border is thin, concave, and free. The upper surfaces of the menisci are concave, and in contact with the condyles of the femur. Their lower surfaces are flat, and rest upon the head of the tibia. Each meniscus covers approximately the peripheral two-thirds of the corresponding articular surface of the tibia.

Medial meniscus - this attaches to the tibia via meniscotibial (coronary ligaments). Its anterior portion is thin and pointed, and is attached to the anterior intercondyloid fossa of the tibia, in front of the anterior cruciate ligament. Its posterior end is fixed to the posterior intercondyloid fossa of the tibia, between the attachments of the lateral meniscus and the posterior cruciate ligament. It is fused with the tibial collateral ligament which makes it far less mobile than the lateral meniscus. The points of attachment are relatively widely separated and, because the meniscus is wider posteriorly than anteriorly, the anterior portion is considerably thinner than the posterior portion. The medial meniscus covers approximately 64% of the medial tibial plateau. The greatest displacement of the meniscus is caused by external rotation, while internal rotation relaxes it. During rotational movements of the tibia, when the knee is flexed, the
medial meniscus remains relatively fixed while the lateral part of the lateral meniscus is displaced across the tibial condyle below.

**Lateral meniscus** - this meniscus is nearly circular, and covers a larger portion of the articular surface than the medial one. It is grooved laterally for the tendon of Popliteus, which separates it from the fibular collateral ligament. Its anterior end is attached in front of the intercondyloid eminence of the tibia, laterally and behind the anterior cruciate ligament, with which it blends. The anterior attachment of the lateral meniscus is twisted on itself so that its free margin looks backward and upward, its anterior end resting on a sloping shelf of bone on the front of the lateral process of the intercondyloid eminence. The posterior end is attached behind the intercondyloid eminence of the tibia and in front of the posterior end of the medial meniscus. The lateral meniscus covers approximately 84% of the lateral tibial plateau.

Close to its posterior attachment it gives off a small band of fibres (fasciculus), known as the posterior meniscofemoral ligament, or the ligament of Wrisberg, passing upward and medially to insert into the medial condyle of the femur, immediately behind the attachment of the posterior cruciate ligament. Occasionally a small fasciculus passes forward to be inserted into the lateral part of the anterior cruciate ligament, known as the posterior meniscofemoral ligament, or ligament of Humphry, although only 6% of knee joints have both ligaments present. The lateral meniscus also gives off a fasciculus from its anterior convex margin which forms the transverse ligament.
The arterial supply to the joint is via the anastomoses of five major arteries, whose position is fairly constant. These are the:

- Superior medial genicular artery
- Superior lateral genicular artery
- Middle genicular artery
- Inferior medial genicular artery
- Inferior lateral genicular artery

In addition to these vessels, there is also anastomosis with descending genicular arteries, and with the anterior tibial recurrent artery, and all of these vessels originate from either the femoral/popliteal artery.

The menisci are supplied via the inferior and superior lateral and medial genicular arteries, although the supply is not equal to all of the meniscal tissues. There is a maximum of 30% vessel penetration into the menisci from the peripheries, leaving the central areas avascular, and therefore almost impossible to heal should they become damaged.
Movement around the knee joint

The joint allows flexion and extension about a virtual transverse axis, together with some medial and lateral rotation about the axis of the lower leg in the flexed position. The centre of the transverse axis of the is located where both collateral ligaments and both cruciate ligaments intersect. This centre moves upward and backward during flexion, whilst the distance between the centre and the articular surfaces of the femur changes dynamically with the decreasing curvature of the femoral condyles. The total range of motion is dependent on several parameters such as soft-tissue restraints, active insufficiency, and hamstring tightness.

With the knee extended both the lateral and medial collateral ligaments, as well as the anterior part of the anterior cruciate ligament, are taut. During extension, the femoral condyles glide into a position which causes the complete unfolding of the tibial collateral ligament. During the last 10° of extension, an obligatory terminal rotation is triggered in which the knee is rotated medially 5°. The final rotation is produced by a lateral rotation of the tibia in the non-weight-bearing leg, and by a medial rotation of the femur in the weight-bearing leg. This terminal rotation is made possible by the shape of the medial femoral condyle, assisted by the iliotibial tract and is caused by the stretching of the anterior cruciate ligament. Both cruciate ligaments are slightly unwound, and both lateral ligaments become taut.

In the flexed position, the collateral ligaments are relaxed while the cruciate ligaments are taut. Rotation is controlled by the twisted cruciate ligaments; the two ligaments get twisted around each other during medial rotation of the tibia, reducing the amount of rotation possible, and then unwind during lateral rotation of the tibia. Because of the oblique position of the cruciate ligaments at least a part of one of them is always tense and these ligaments control the joint as the collateral ligaments are relaxed. Furthermore, the dorsal fibres of the tibial collateral ligament become tensed during extreme medial rotation and the ligament also reduces the lateral rotation to 45-60°.