Bony Anatomy of the Foot and Ankle Complex

Erick J Janisse, CO, CPed

Bones

Bones are made of connective tissue reinforced with calcium and specialized bone cells. Most bones also contain bone marrow, where blood cells are made. Bones work with muscles and joints to hold our body together and support freedom of movement. This is called the musculoskeletal system.

What is bone made of?

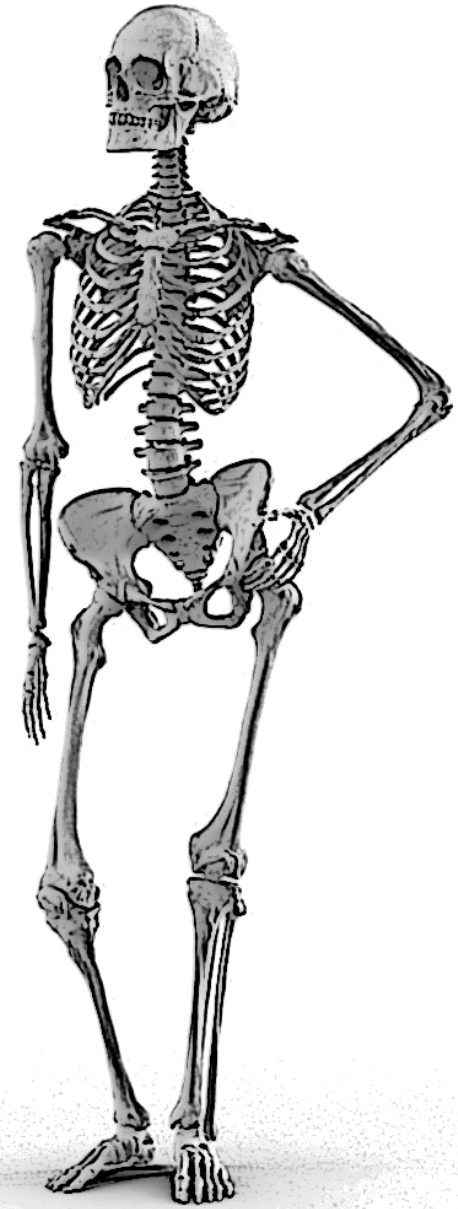
- Bone is made of protein, collagen, and minerals, especially calcium. Collagen provides a framework for the incorporation of mineral, mainly calcium phosphate into the collagen framework. The mineral makes bone hard and strong while the collagen provides flexibility so that the bone can resist breaking.
- Each bone has two types of bone tissue to ensure strength: The dense, hard outer layer is called compact or cortical bone while the inner, less dense, lattice-like bone is called cancellous, trabecular or spongy bone that is surrounded by bone marrow.

What does bone do?

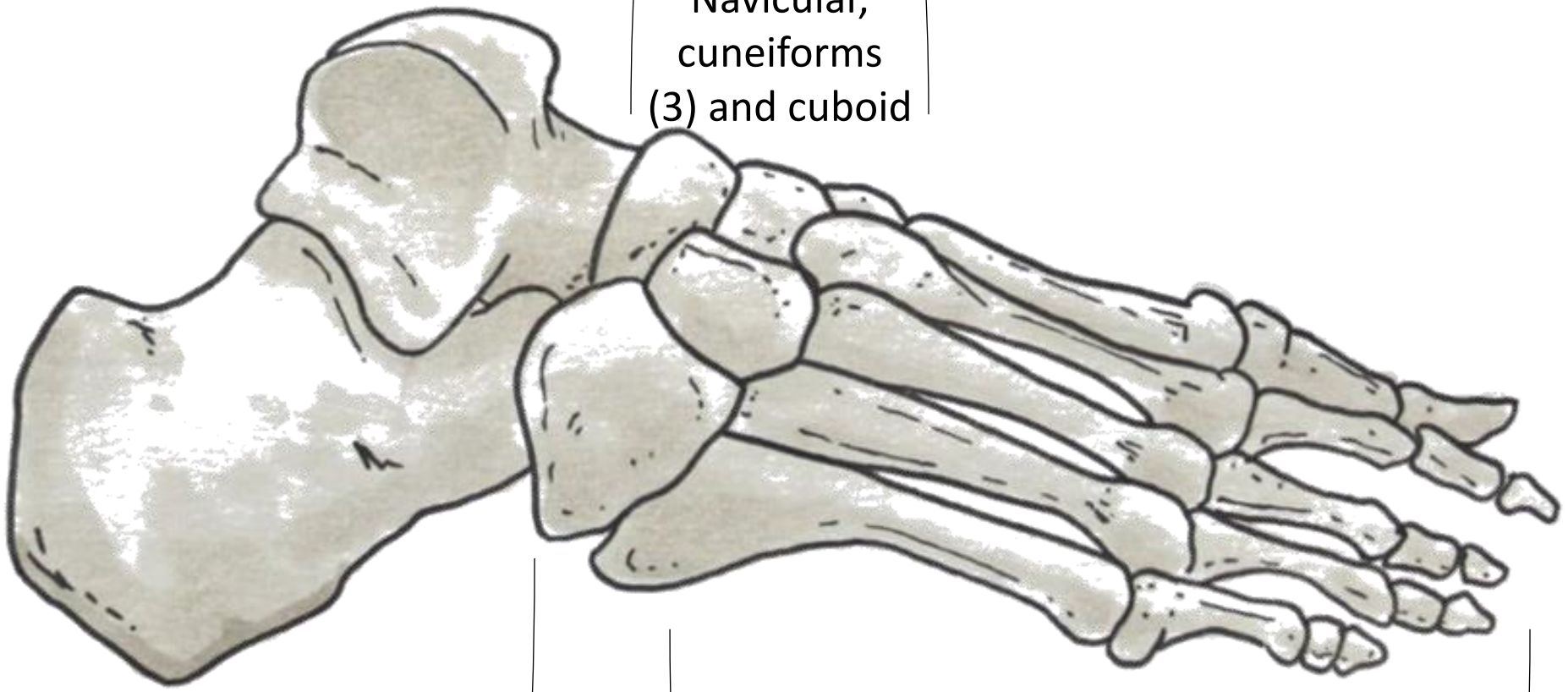
- Bone has many important jobs in the body:
  - The skeleton is made of bone to provide a strong framework to support and protect the soft organs (such as the brain, heart, and lungs) from injury.
  - Bone works with muscle to hold up the body when we stand and to move the body when we walk or run.
  - Bone houses the bone marrow, which makes blood cells.
  - Bone stores growth factors and minerals such as calcium.
  - Bone releases factors into the blood that are necessary for normal functioning of soft organs such as the kidney.
- The human body needs calcium to build and maintain bones and to ensure all cells in the body work properly. Not only do bones require calcium for growth and health, but bones also require other factors and nutrients such as vitamin D to function normally.
- Exercise is also very important for normal bone growth and for adult bone health. Our skeletons require the stresses and loading that occurs with movement and exercise to keep our bones healthy throughout life.

Bones

- There are 206 bones in the human body
- There are 28 bones in each foot
  - 26 + 2 sesamoid bones



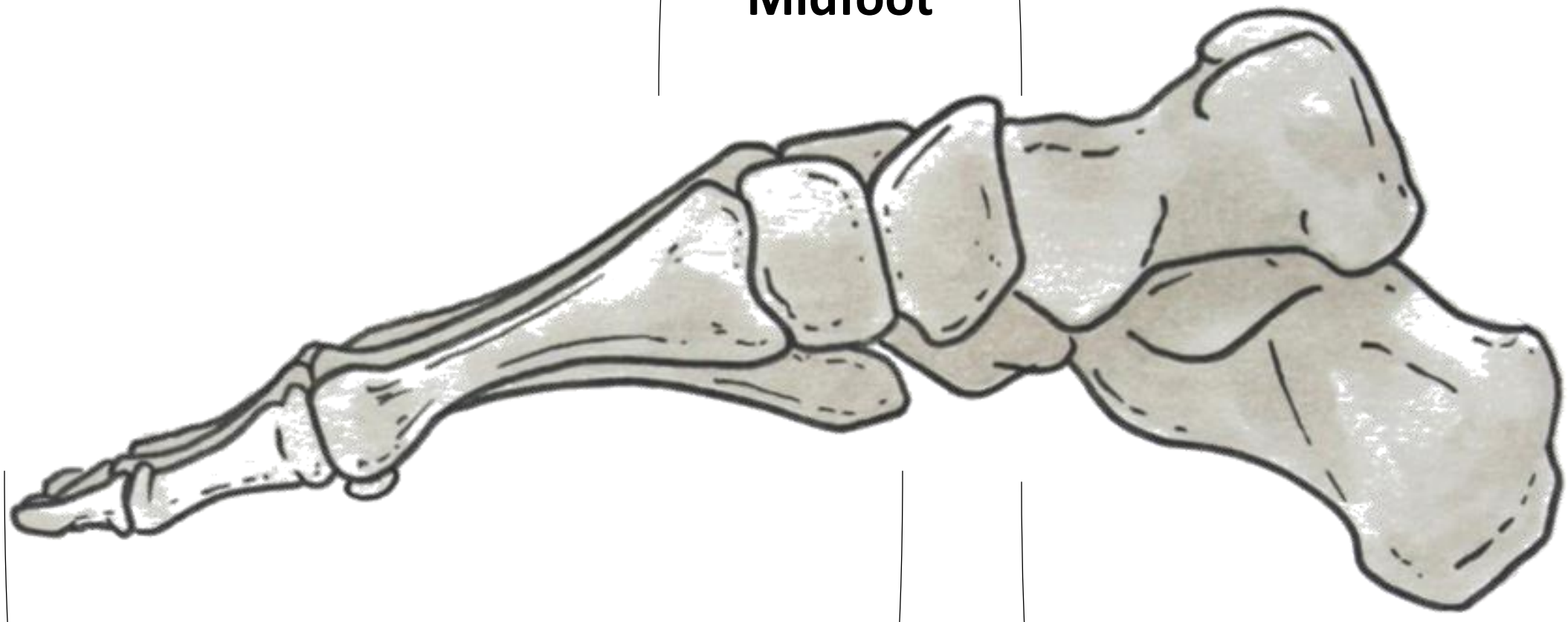
Midfoot
Navicular, cuneiforms (3) and cuboid



Rear foot/Hind foot
Talus and calcaneus

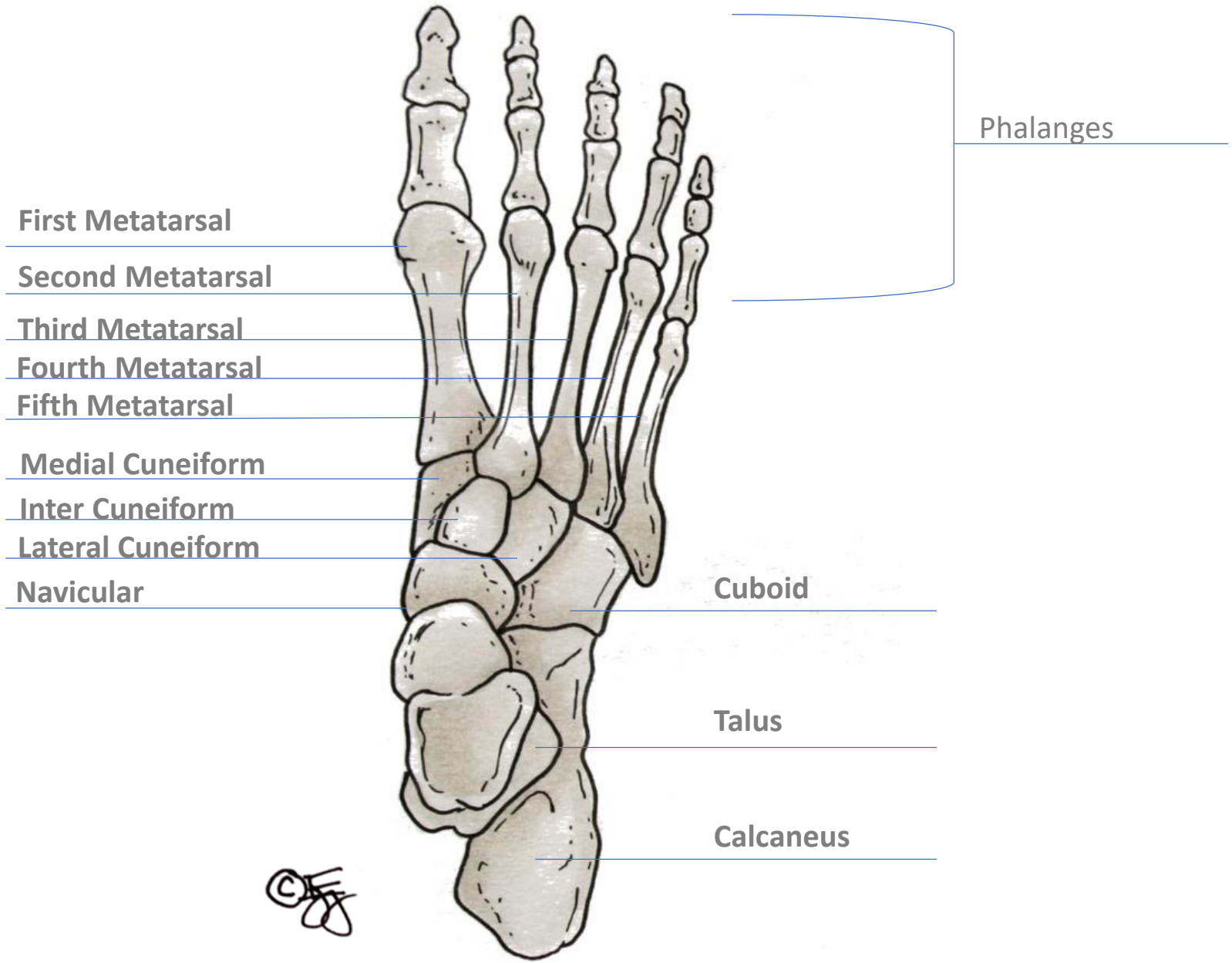
Forefoot
Metatarsals (5) and phalanges (14)

Midfoot



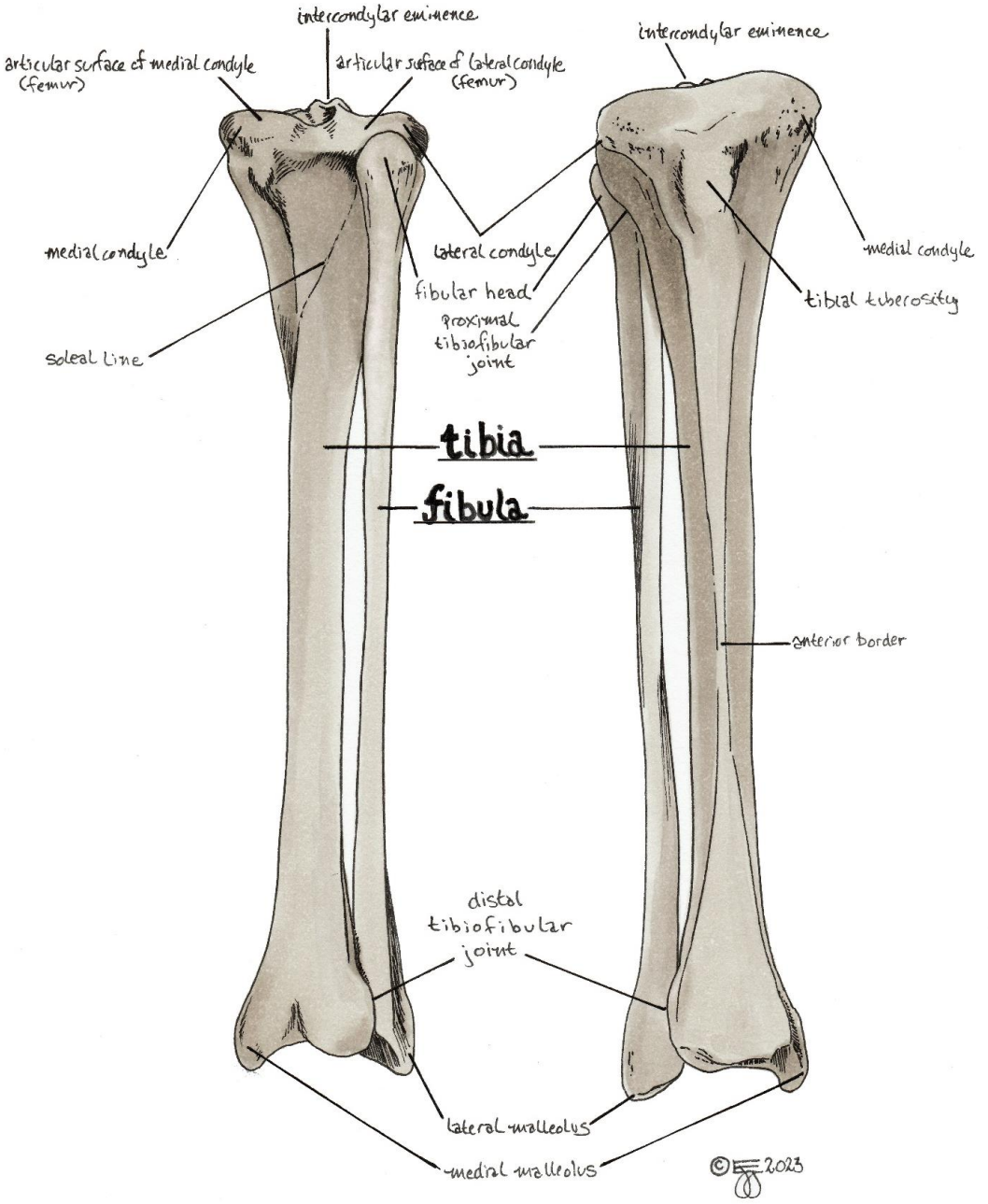
Forefoot

Hindfoot/Rearfoot


Phalanges
First Metatarsal
Second Metatarsal
Third Metatarsal
Fourth Metatarsal
Fifth Metatarsal
Medial Cuneiform
Inter Cuneiform
Lateral Cuneiform
Navicular
Cuboid
Talus
Calcaneus

Tibia and Fibula

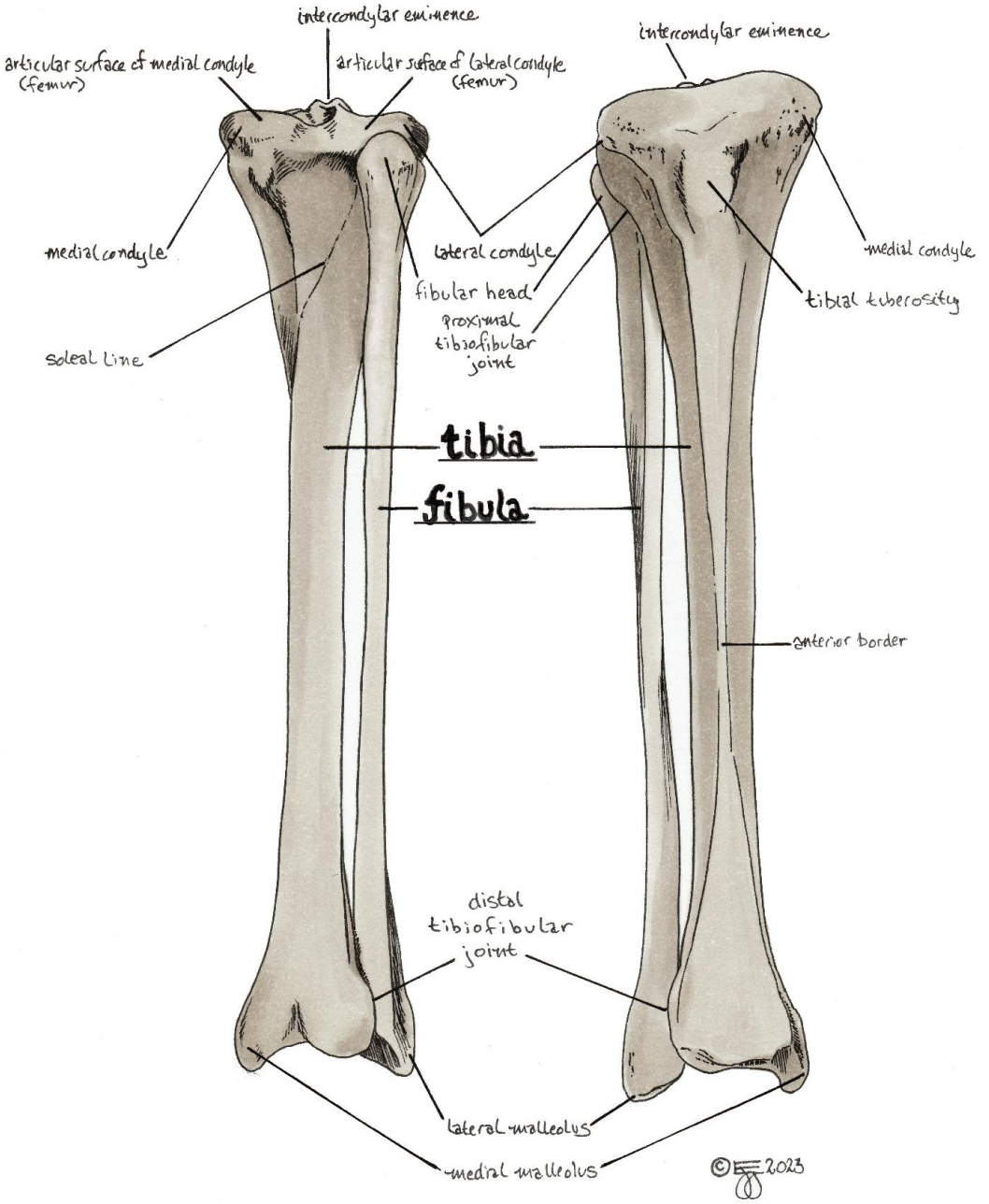
- The tibia and fibula are the two bones that form the lower leg.
- The tibia is longer and forms part of the knee at its top (proximal) end and your ankle at its lower (distal) end.
- The fibula is closer to the outside of the body (lateral) than the tibia.
- The tibia is weight-bearing, which means it supports the body when one stands and moves.
- The fibula doesn't support as much weight and mostly provides structural support to the leg.
- The distal ends (base) of the tibia and fibula form the ankle joint with the talus.



Tibia

- The tibia is second longest bone in the body. It plays an important role in l one stands, moves and keeps one's balance.

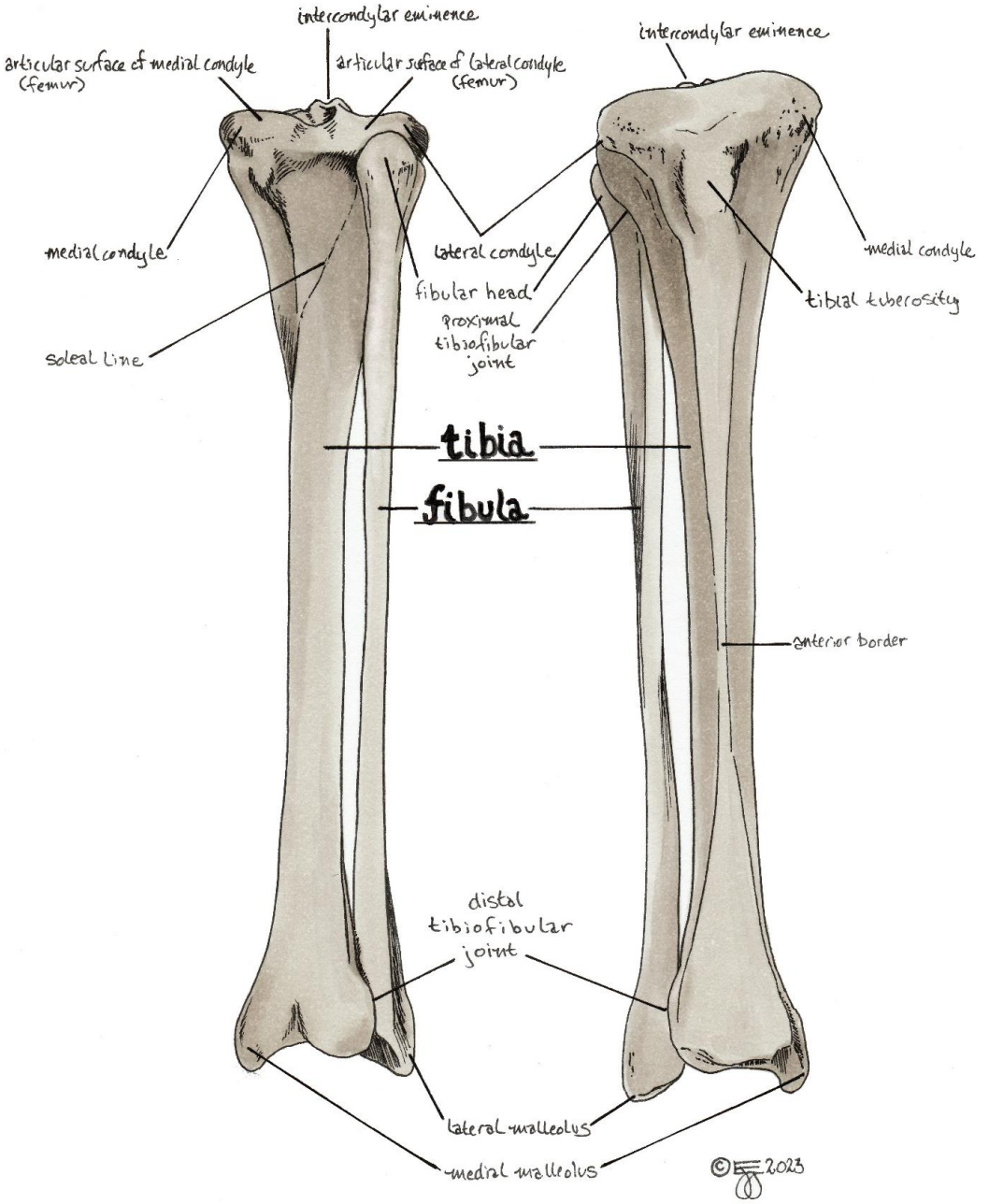
- **Tibia proximal aspect**
  - The upper (proximal) end of the tibia forms the bottom of the knee joint. The proximal end (aspect) contains the:
    - •Medial condyle
    - •Lateral condyle
    - •Intercondylar eminence
- **Tibia shaft**
  - The shaft is the long portion of the tibia that supports one's weight forms the structure of the shin. It's shaped like a three-sided prism. shaft of the tibia includes the:
    - •Anterior border
    - •Posterior surface
    - •Soleal line
    - •Lateral border
- **Tibia distal aspect**
  - The lower (distal) end of the tibia forms the top of the ankle joint. It meets the fibula and calcaneus (ankle bone). It includes the:
    - •Medial malleolus
    - •Fibular notch



Fibula

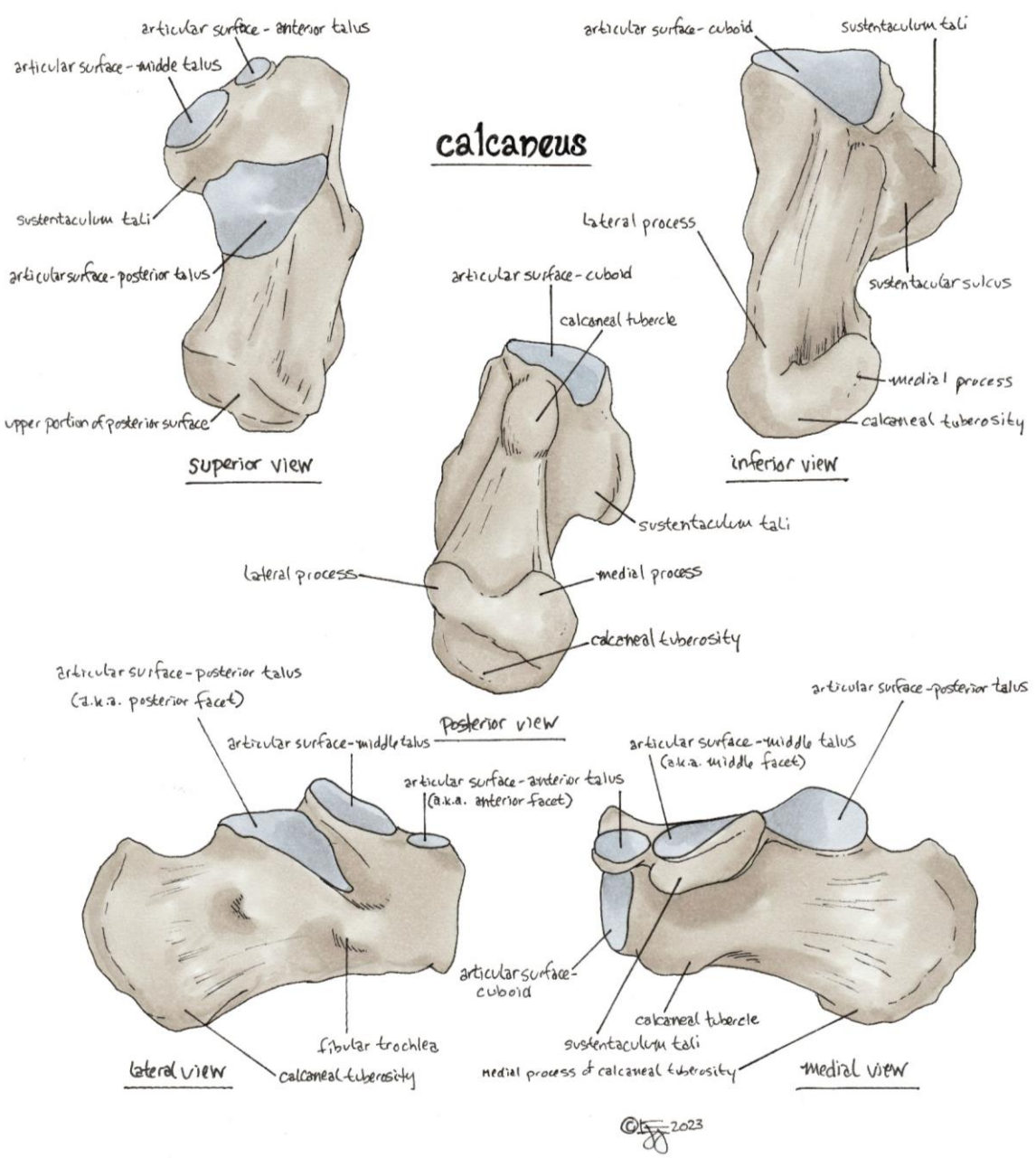
- The fibula is the third longest bone in the body. It isn't weight-bearing, but it supports muscles, tendons and ligaments.

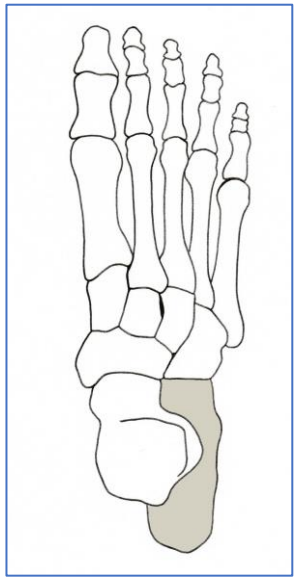
- **Fibula head (proximal aspect)**
  - The upper (proximal) end of the fibula meets the tib and moves with it when one moves the knee joint.
- **Fibula shaft**
  - The shaft is the long portion of the fibula that forms structure of the calf. It's shaped like a three-sided pri
- **Fibula distal aspect**
  - The lower (distal) end of the fibula forms the top of t ankle joint. It articulates with the tibia and the talus.



Calcaneus

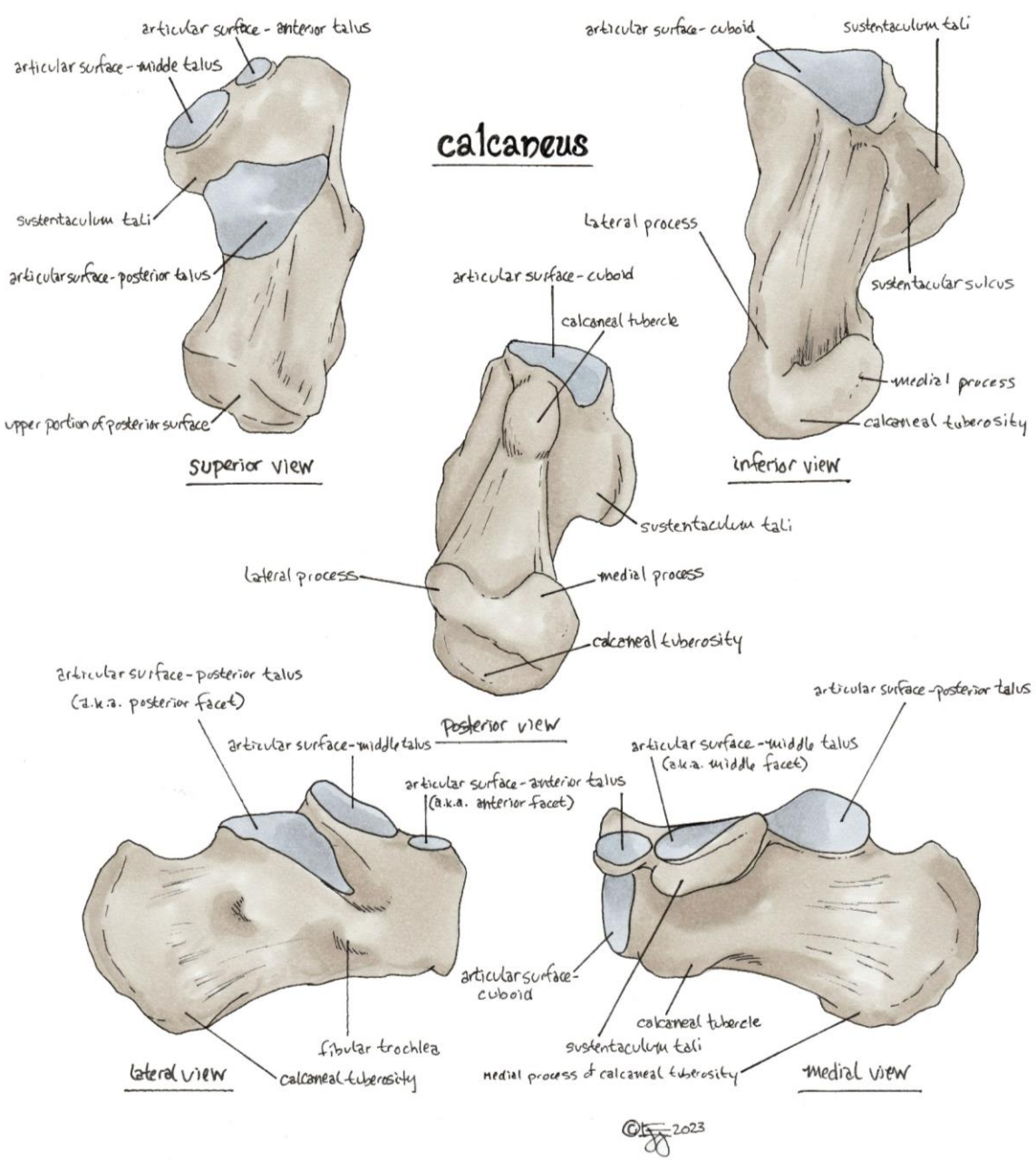
- One of the seven articulating bones that make up the tarsus. The calcaneus is located in the hindfoot with the talus and is the largest bone of the foot.
- It is commonly referred to as the heel.
- Numerous ligaments and muscles attach to the calcaneus and help with its role in human bipedal biomechanics.
- It articulates with the talus superiorly and the cuboid anteriorly and shares a joint space with the talocalcaneonavicular joint.
- The calcaneus transfers most of the body weight from the lower limb to the ground.

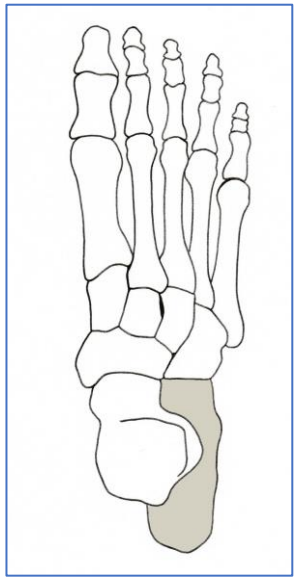




Calcaneus

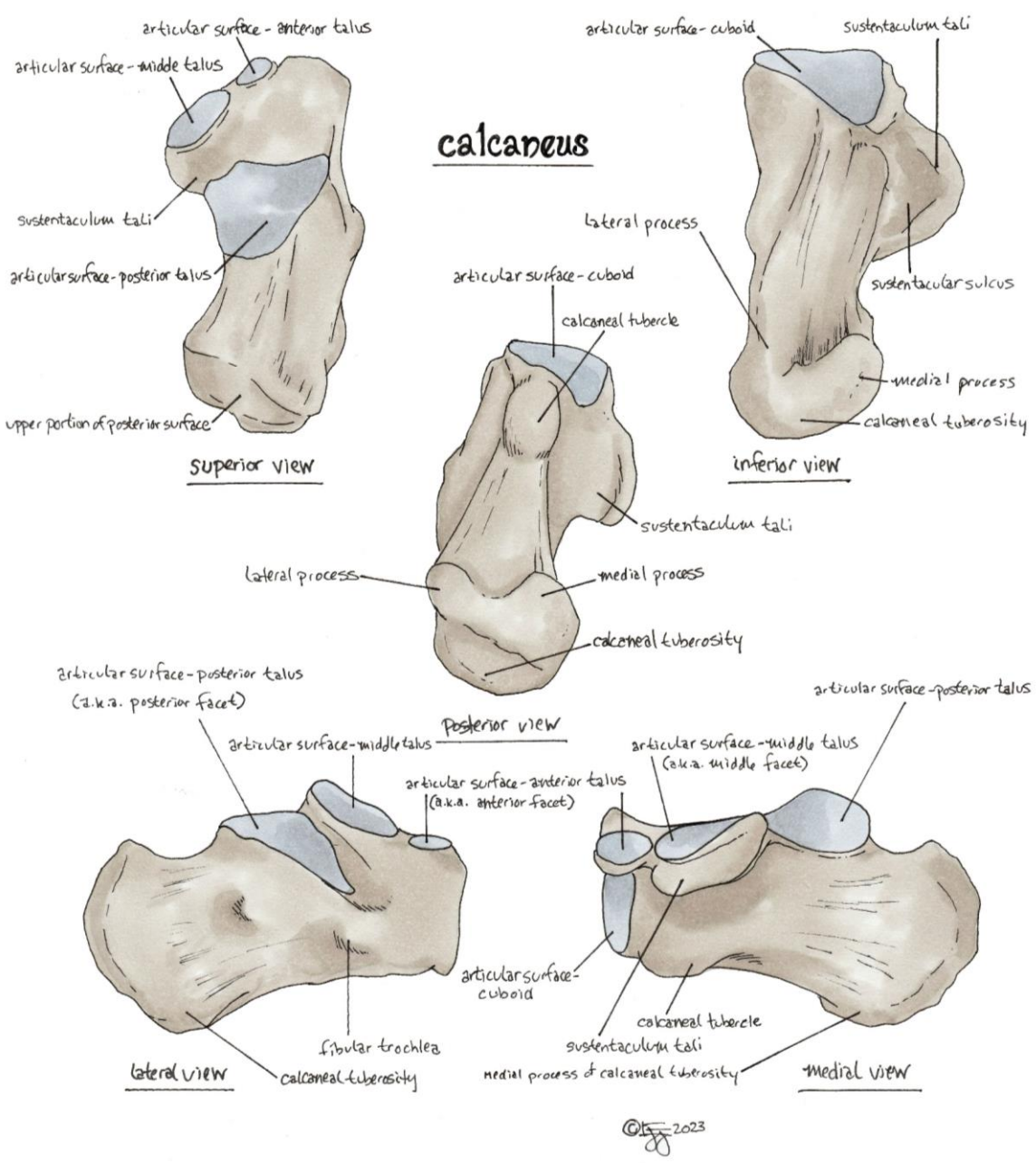
- The calcaneus is a roughly box-shaped bone that sits below the talus. Its long axis is orientated along the mid-line of the foot, however, deviates lateral to the mid-line anteriorly. It projects posteriorly to form the core of the heel.
- Protruding anteromedially from upper margin of the medial surface is the *sustentaculum tali.* The sustentaculum tali is easily palpable and supports the more posterior part of the head of the talus.
- Superiorly is the middle talar articular facet for the corresponding middle facet of the head of talus as part of the subtalar joint.
- The anterior and posterior facets of the talocalcaneal joint are on the superior surface of the calcaneus. Between these two facets runs the calcaneal sulcus which, together with the opposing talar sulcus, forms the tarsal sinus.
- The anterior surface has a convex articular facet for the cuboid bone.

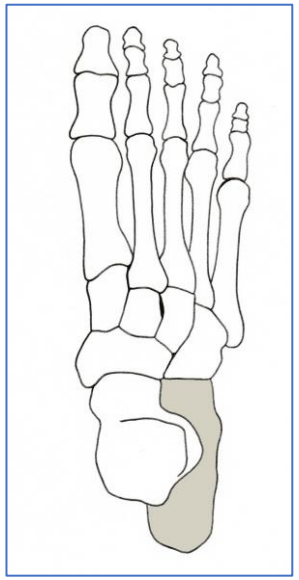




Calcaneus

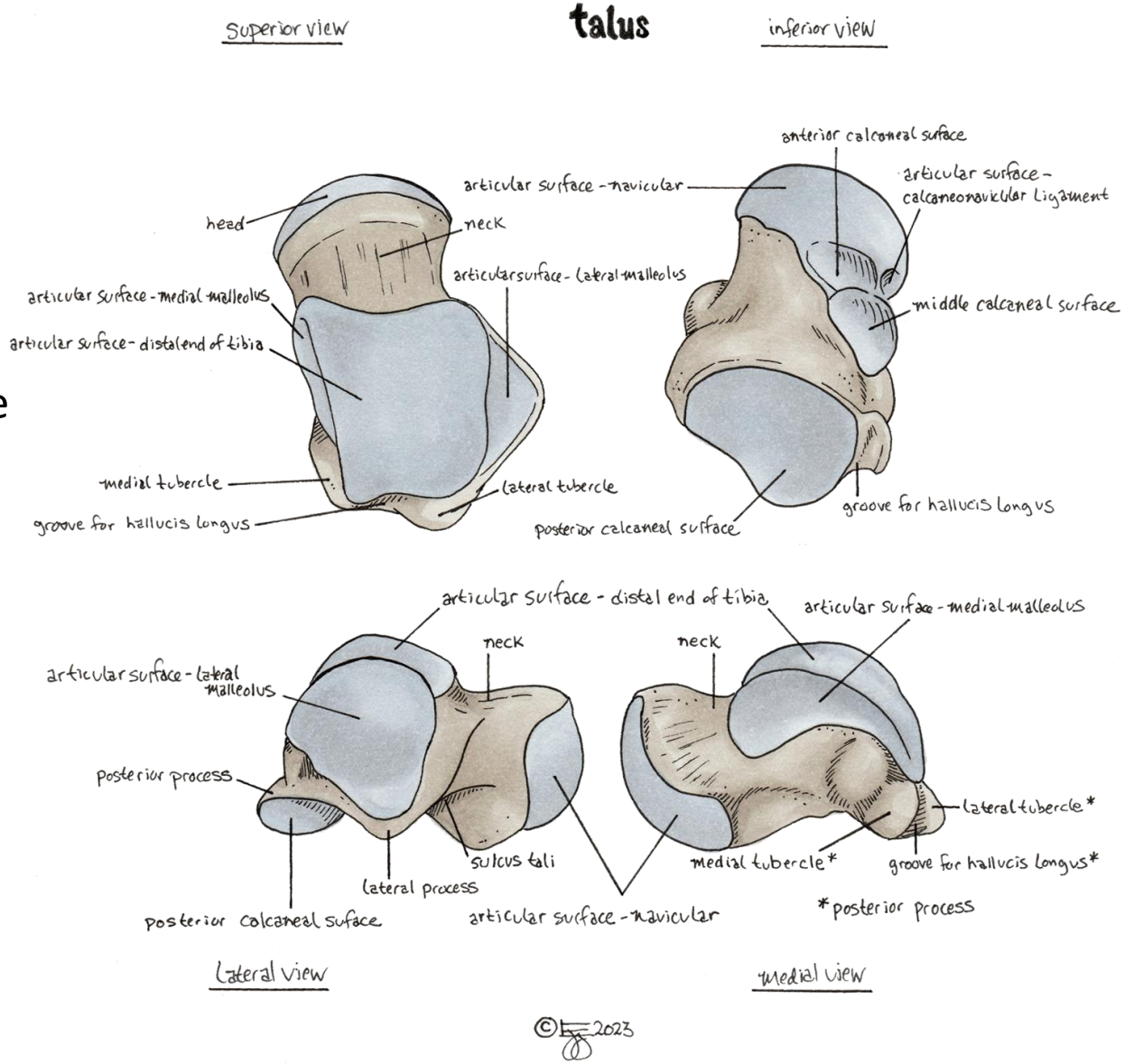
- Articulations
  - Superiorly, the calcaneus articulates with the talus at the subtalar joint, making contact at anterior, middle and posterior facets.
  - The anterior part of the talocalcaneal joint and the talonavicular joint are collectively known as the talocalcaneonavicular joint.
  - Anteriorly, the calcaneus articulates with the cuboid, forming the calcaneocuboid joint.

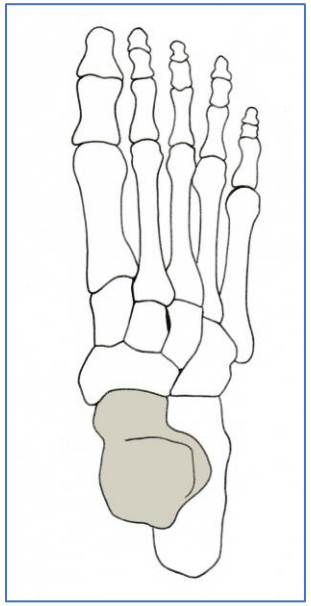




Talus

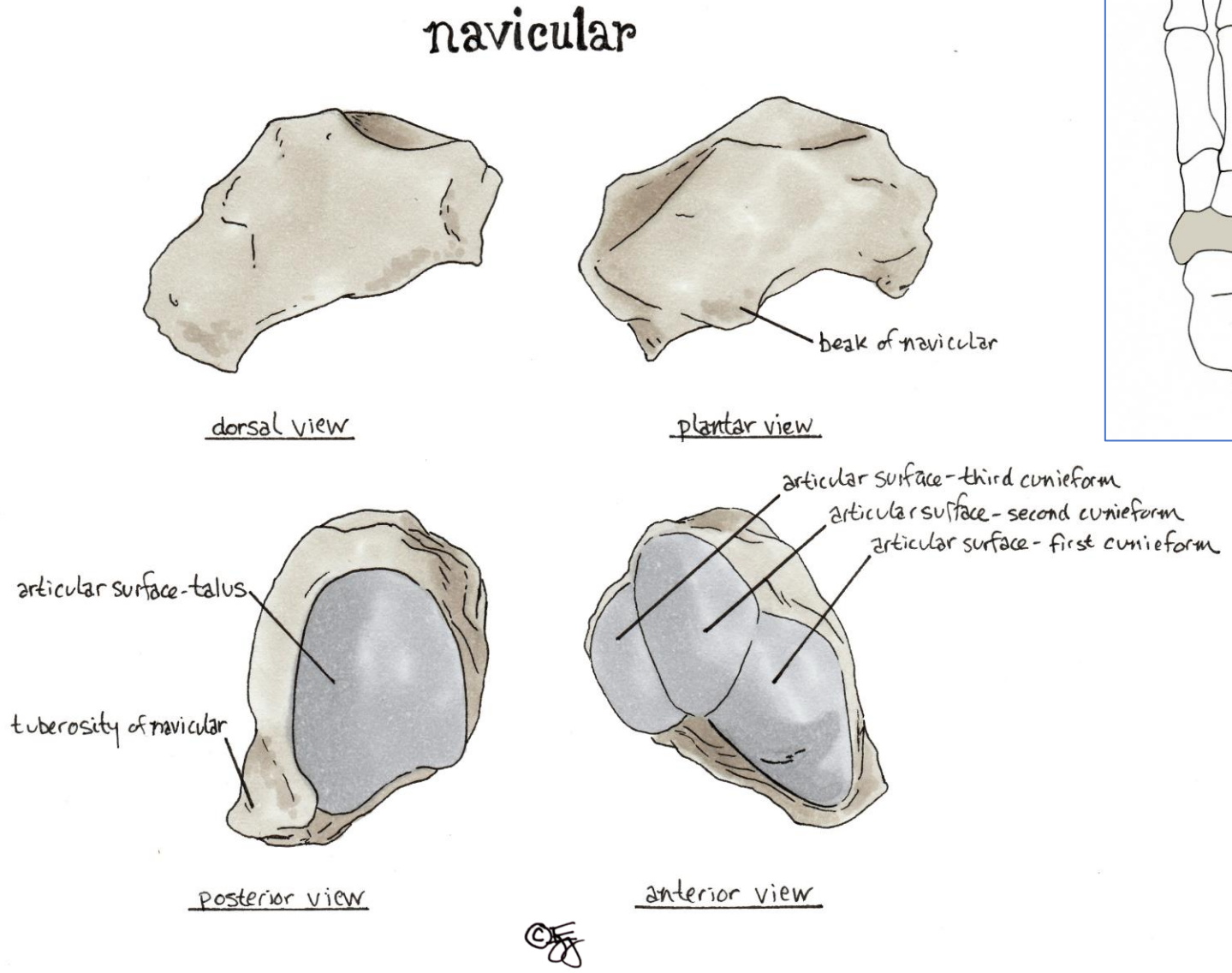
- The talus is the second largest bone in the hindfoot region of the human body.
- Is a component of many multiple joints, including the ankle, subtalar, and transverse tarsal joints.
- Articulates with the tibia, fibula, calcaneus and navicular.
- Has no tendinous attachments.
- Moored with several strong ligamentous attachments.
- Has a tenuous and limited blood supply.

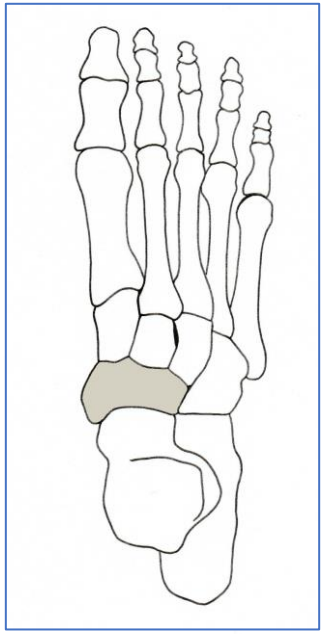




Navicular

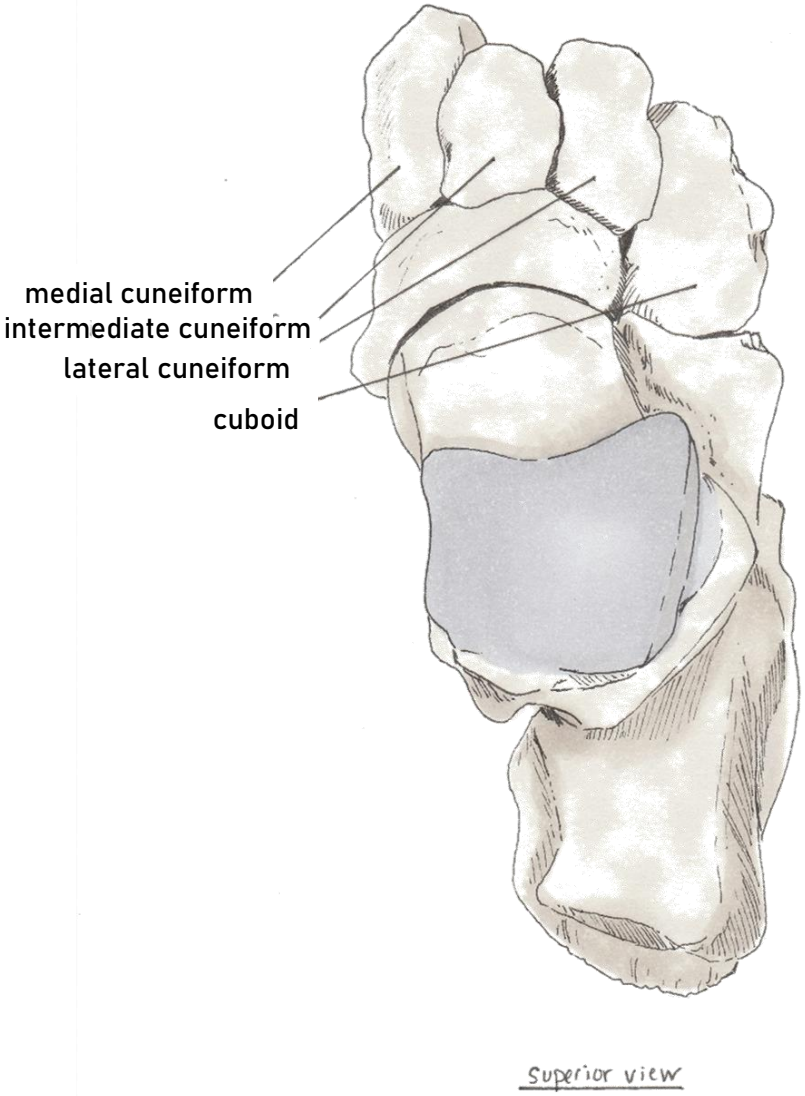
- Also called the *scaphoid* bone.
- Pyriform in shape with oblique long axis, angled slightly downward and medially.
- Is interposed between the head of the talus and the three cuneiforms.
- Minimal articular contact with the cuboid.
- Firmly connected to the calcaneus by ligaments.

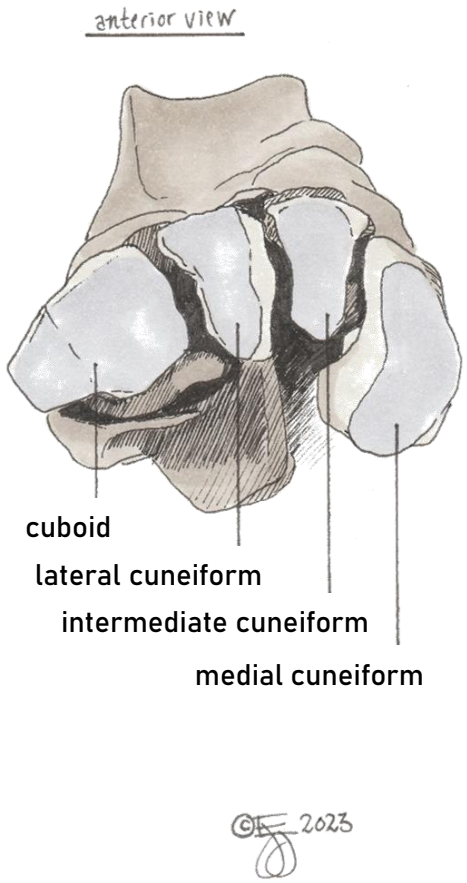


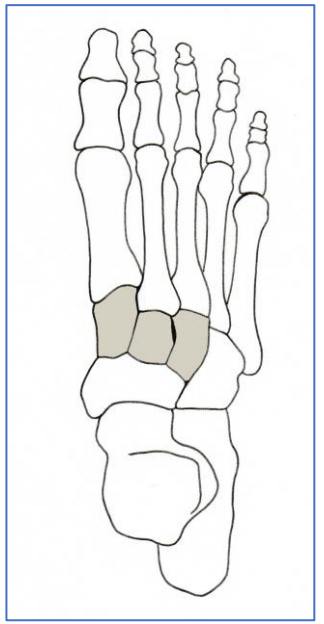


Cuneiforms

- The three cuneiform bones are interposed between the navicular proximally, the first three metatarsals distally, and the cuboid laterally.
- Also called 1st (medial), 2nd (intermediate), and 3rd (lateral).
- The cuneiforms are wedge-shaped, with the narrow side down. Along with the cuboid, they form the transverse arch.

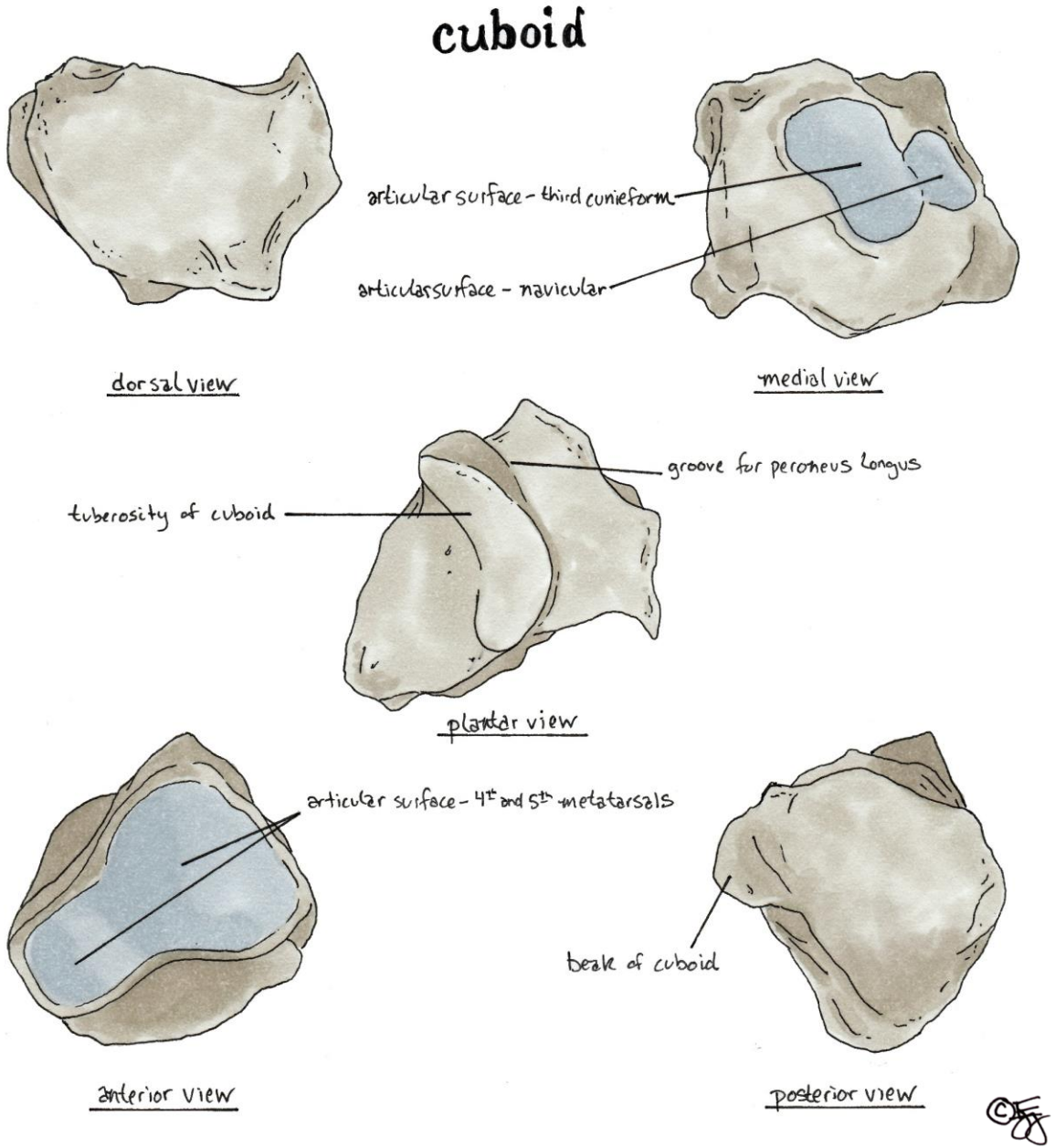


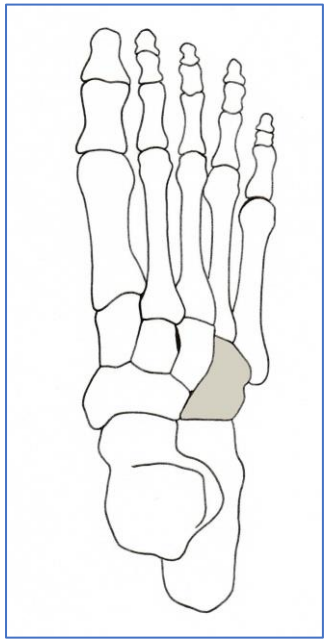




Cuboid

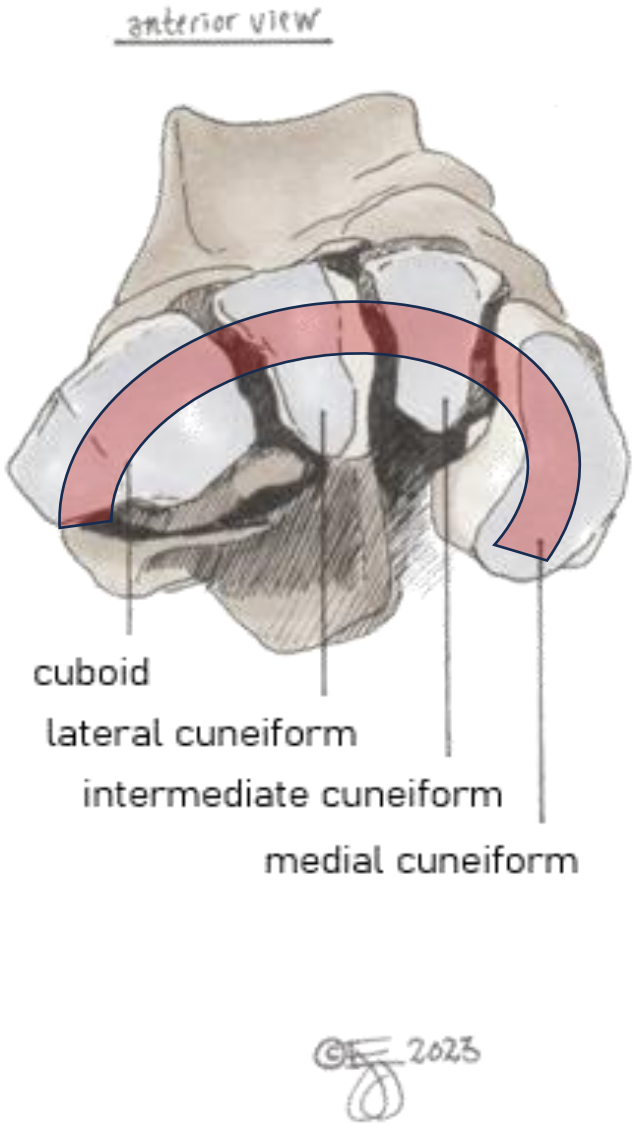
- The cuboid bone is located between the calcaneus and the 4th and 5th metatarsals.
- Despite its name, the cuboid is more wedge-shaped than cube shaped.
- Gives support to the lateral cuneiform and forms the transverse arch with the cuneiform bones.





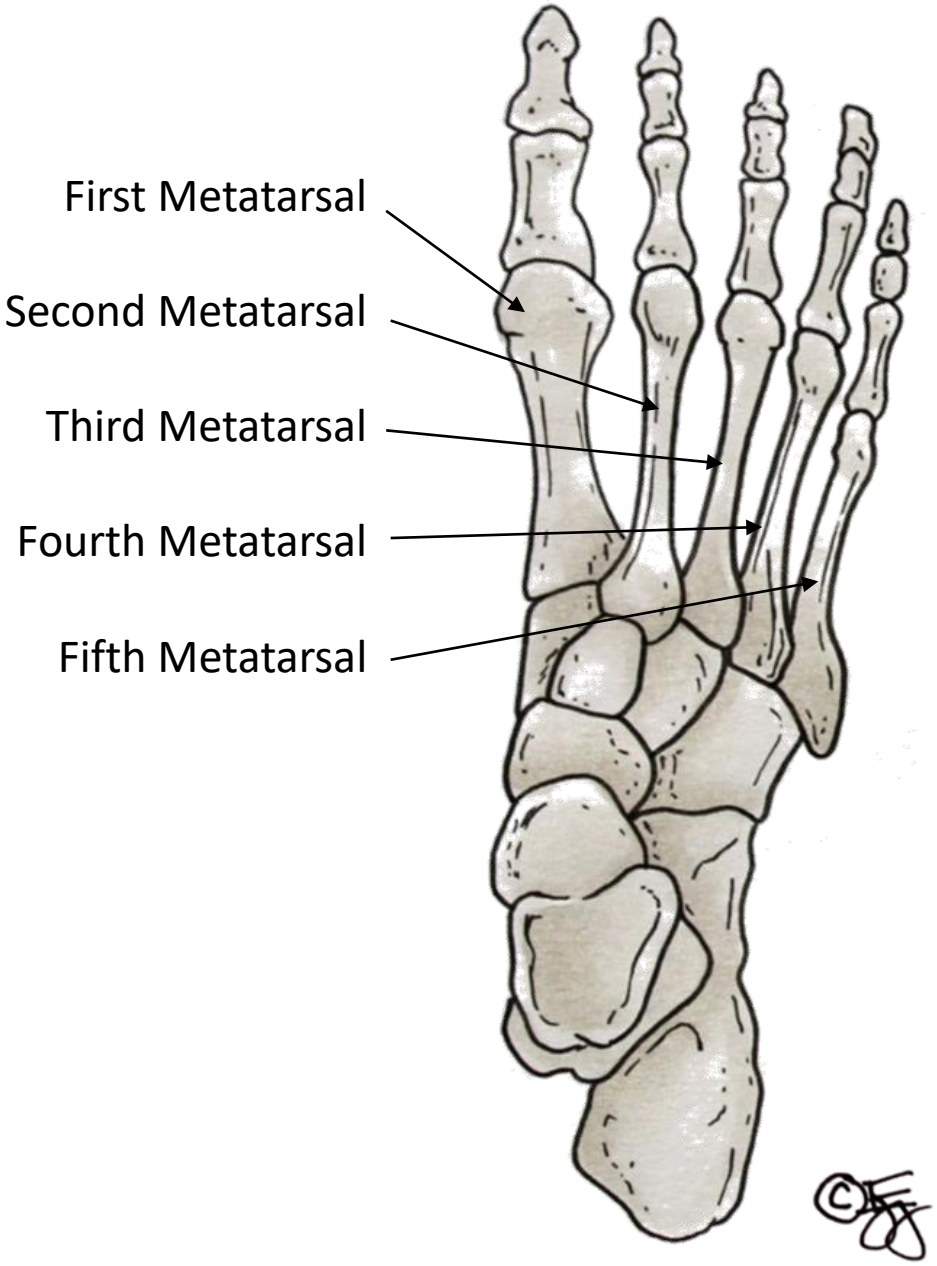
Transverse Arch

- Transverse arch is formed by four wedge-shaped bones:
  - Cuboid
  - Lateral cuneiform
  - Intermediate cuneiform
  - Medial cuneiform
- The transverse arch has a predominant role in the midfoot stiffness that allows the human foot to store elastic energy at the time of heel strike, which is utilized during the push-off mechanism for propulsion, thus making bipedal ambulation more energy-efficient.
- The transverse arch allows the longitudinal arch to be flexible like a lever and, at the same time, makes the arch of the foot rigid to behave like a stiff spring lever.



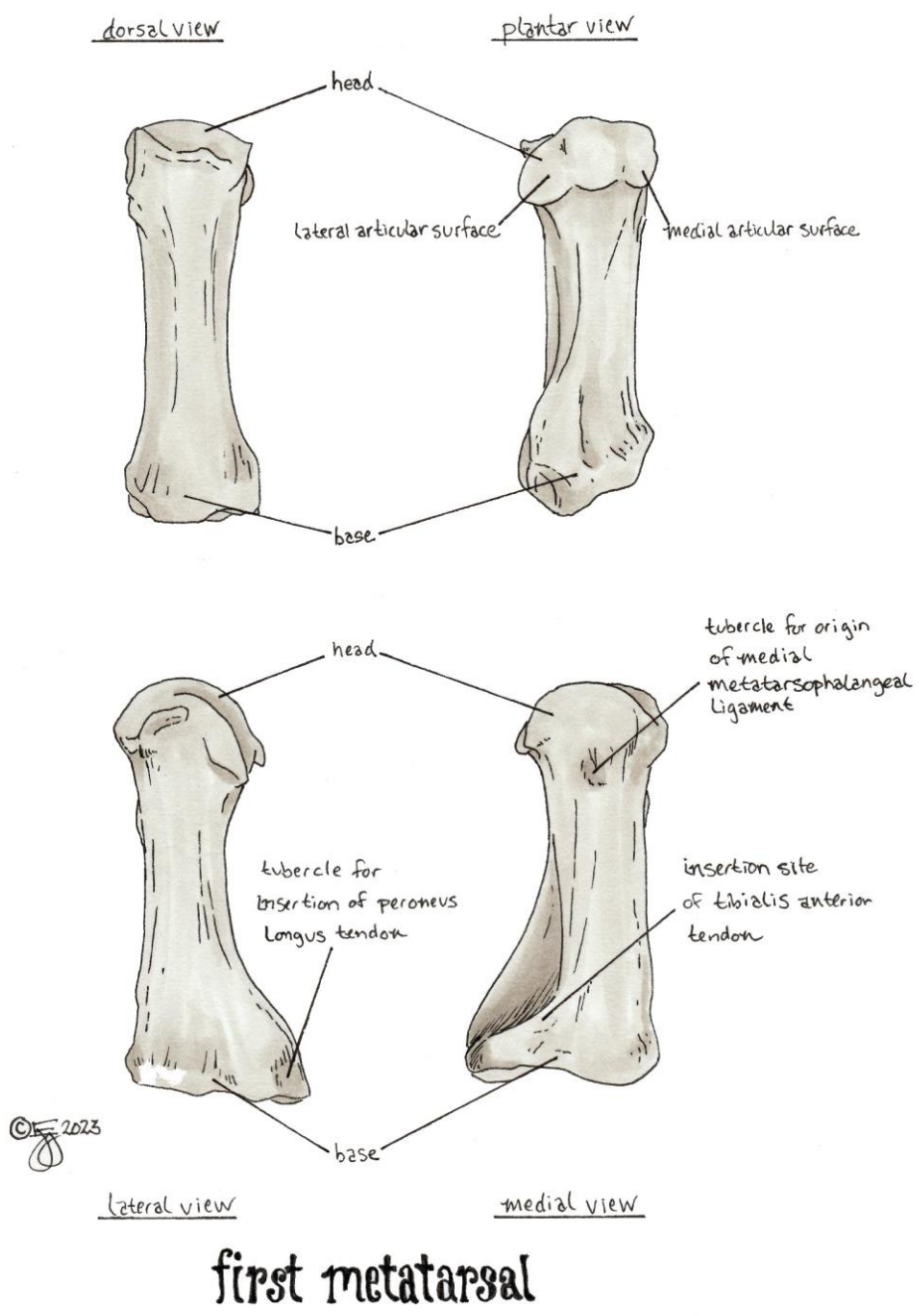
Metatarsals

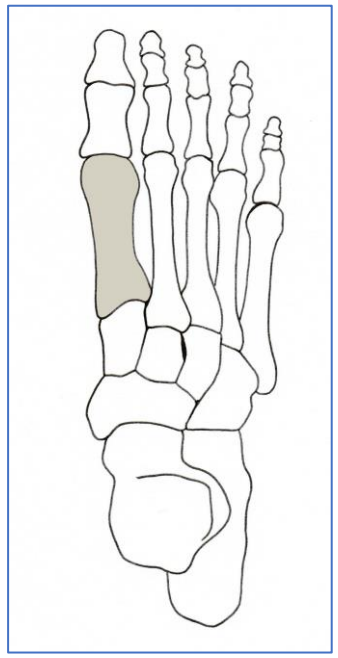
- The five metatarsals articulate proximally with the three cuneiforms and the cuboid to form the tarsometatarsal (Lisfranc's) joint.
- Proximally, the bases of the metatarsals situated in an arch shape, higher on the medial side. The apex of this arch corresponds to the base of the second metatarsal.
- Distally, the heads of all five metatarsals are in the same plane horizontally and no transverse arch is present.
- The metatarsals are also "flexed" which contributes to the formation of the medial (and lateral, to a lesser degree) longitudinal arch.



1st Metatarsal

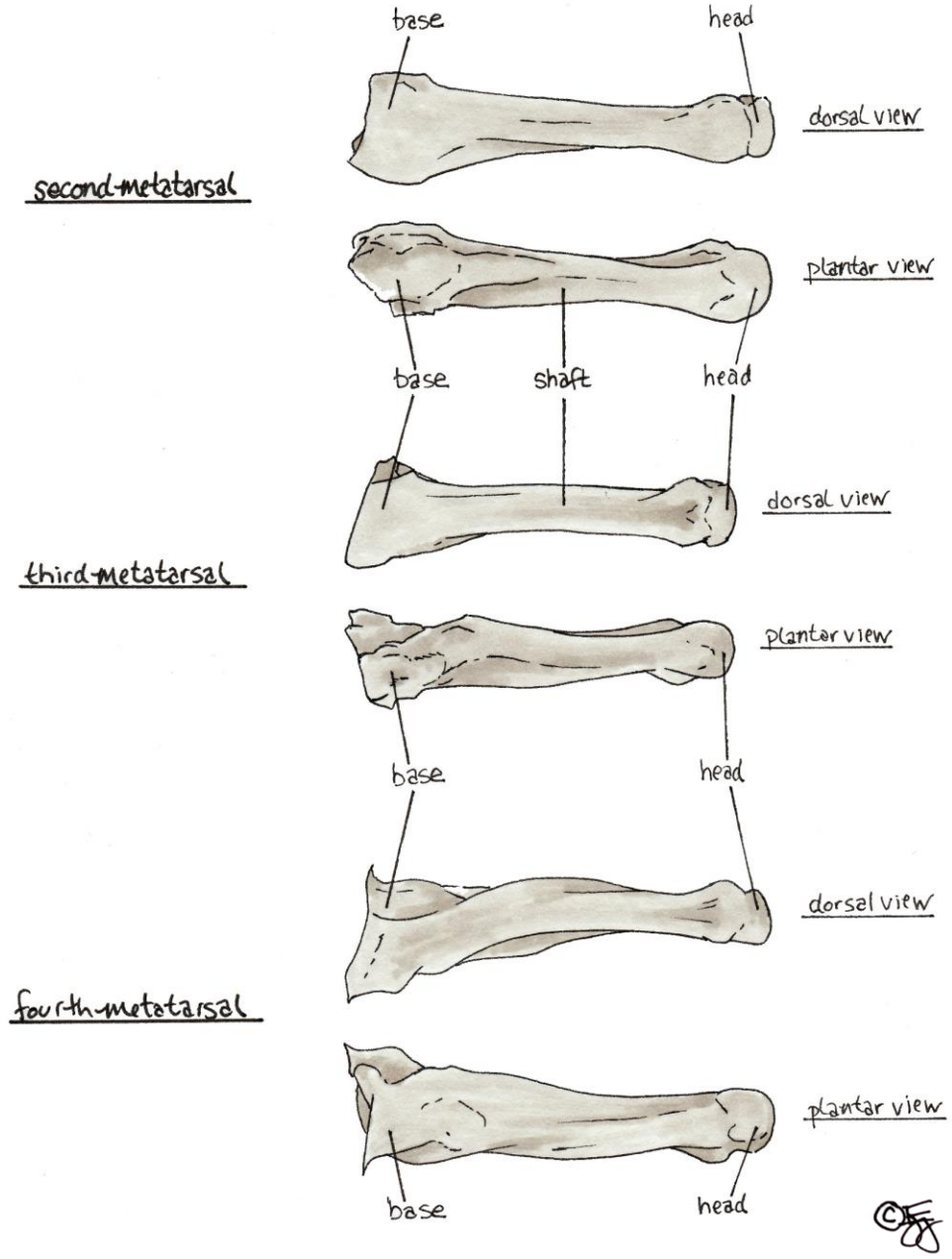
- The first metatarsal bone corresponds to the big toe and is the shortest, thickest and strongest metatarsal.
- The first metatarsal bone, like the rest, consists of a head, a body or shaft, and a base.
- The head points distally towards the toes and connects with the proximal phalanx or the toe bone.
- The first metatarsal head is the most important weight-bearing point in the foot. When standing, the first metatarsal takes 40% of the body's weight.

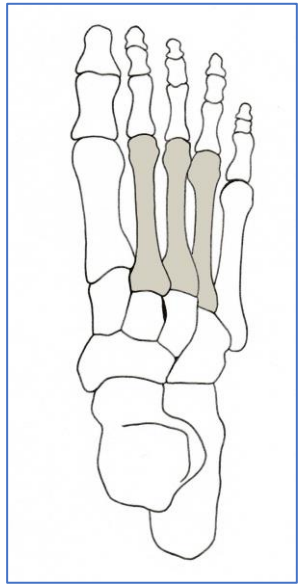




2nd,3rd,4th Metatarsals

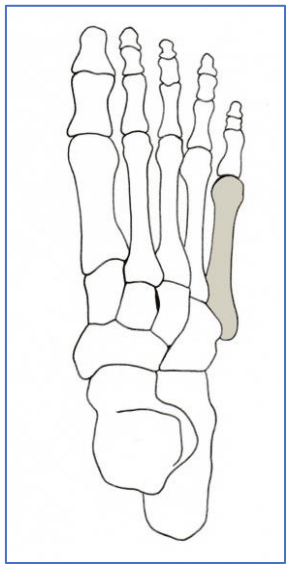
- The second metatarsal is the longest of the metatarsals. Its base articulates proximally with the intermediate cuneiform. It does also contact the medial cuneiform, the bases of the first and third metatarsals, and the lateral cuneiform.
- The third metatarsal is the second longest and its base articulates proximally with the lateral cuneiform. The bone does also make contact with second and fourth metatarsals.
- The fourth metatarsal is the third longest and its base articulates with the cuboid.

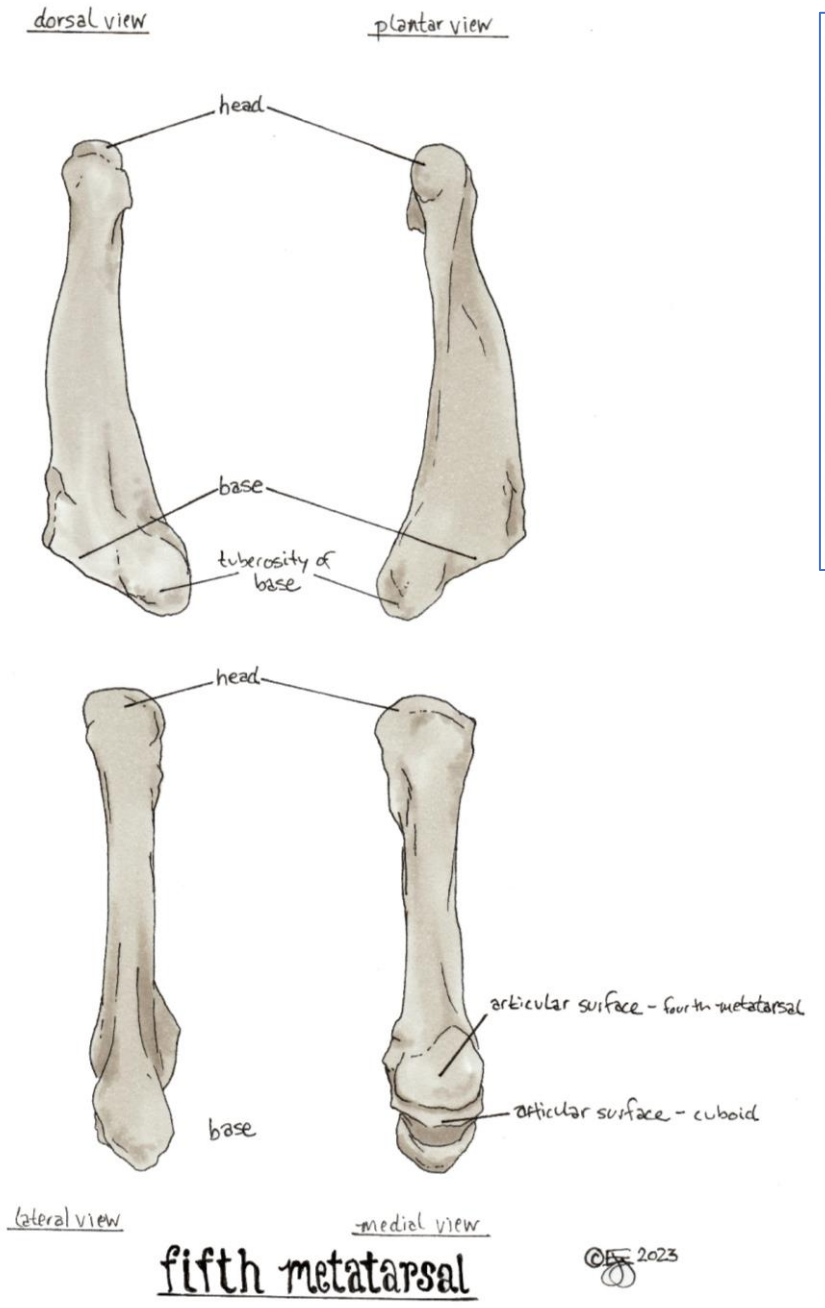




5th Metatarsal

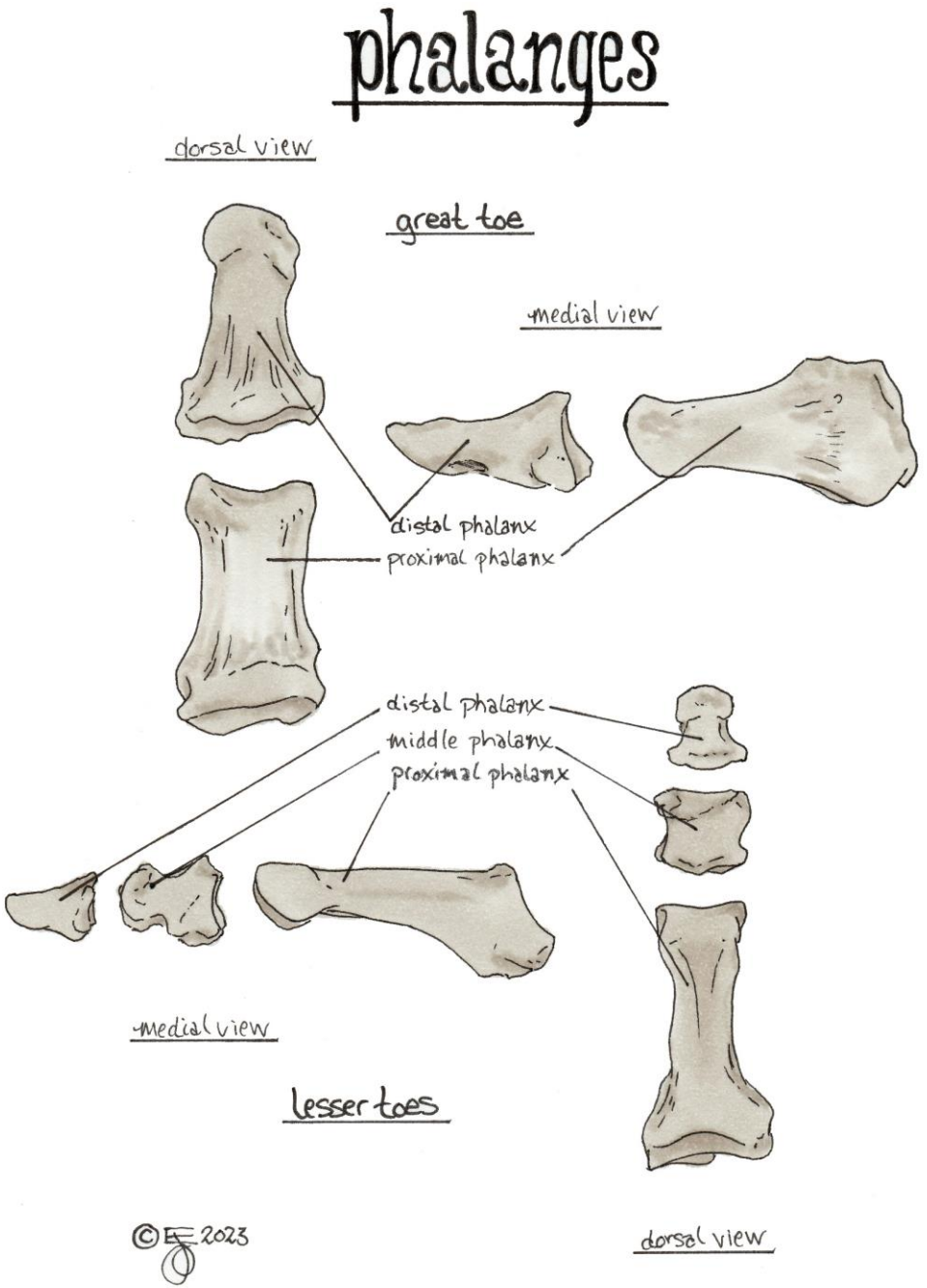
- The fifth metatarsal is the second shortest metatarsal.
- At its base, it articulates with the cuboid.
- The base of the fifth metatarsal projects laterally and posteriorly as the tubercle of the 5th metatarsal (also called the *styloid apophysis*). The peroneus brevis tendon attaches at this point.

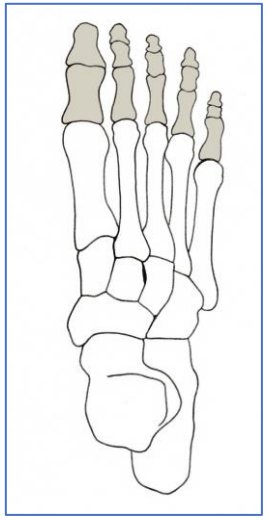




Phalanges

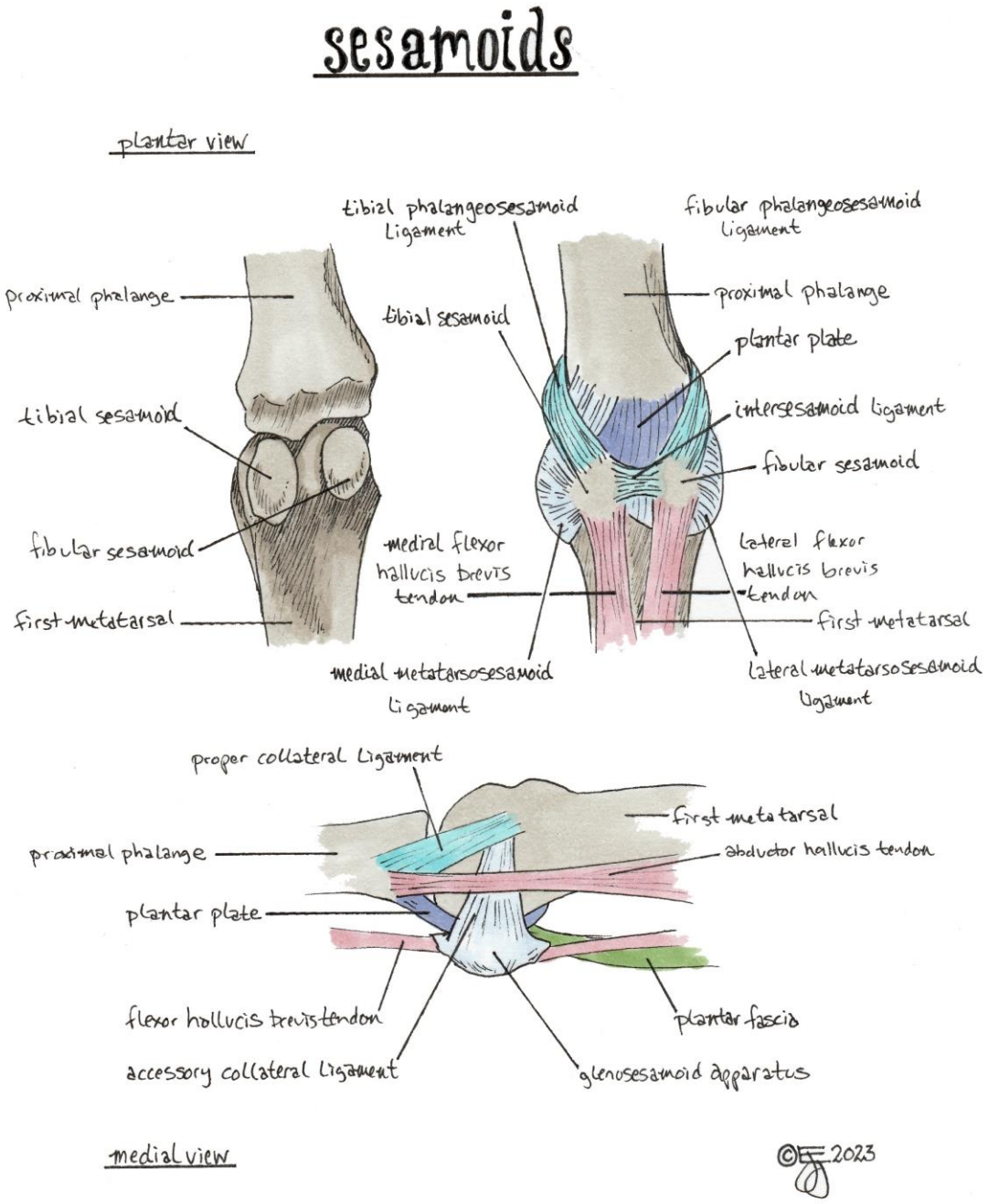
- The 14 phalanges are found in the toes.
  - 2 in the great toe (like the thumb)
  - 3 each in the lesser toes (like the fingers)





Sesamoids

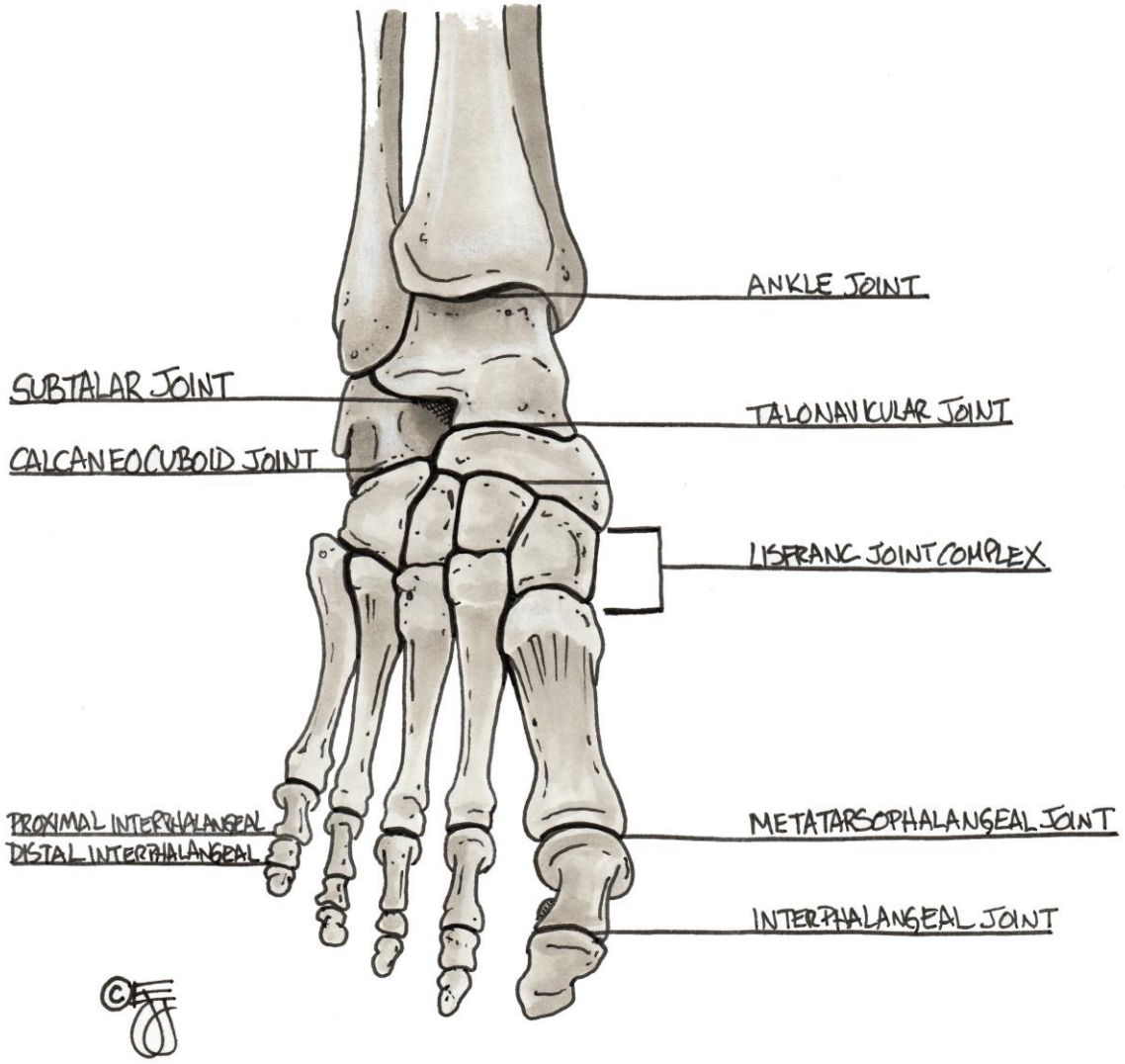
- Sesamoids are small, round bones deriving their name from the sesame seed.
- The overall configuration on the sesamoids varies; they can be circular, ovoid or bean-shaped.
- The tibial (medial) sesamoid is the larger of the two and is usually ovoid and elongated while the fibular (lateral) sesamoid is typically more circular in shape.
- The two sesamoids of the metatarsophalangeal joint are found under the head of the first metatarsal and are embedded in a thick plantar plate.
- Functioning as a sort of pulley for the hallucis brevis tendon, the sesamoids help the great toe move normally and provide leverage during toe off when walking or running.



Joints

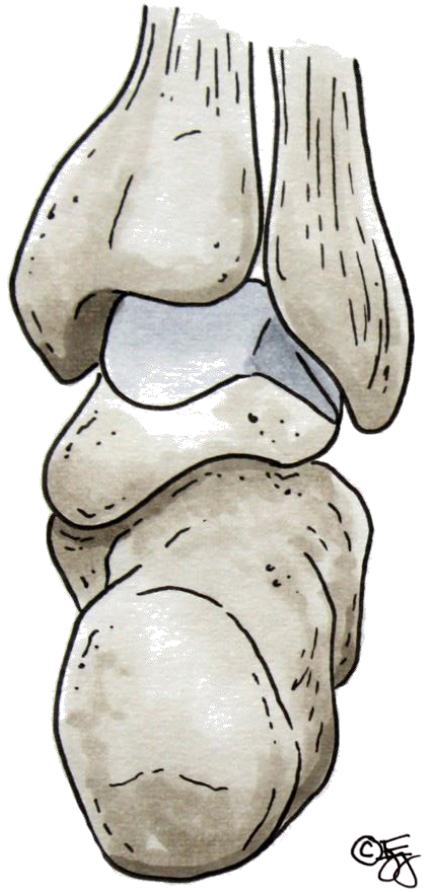
Joints

- Anywhere two bones come together and articulate, that's a joint!
- There are 33 joints in the foot.
- Most joints are named for the bones involved.
- The ROM of the different joints varies greatly.



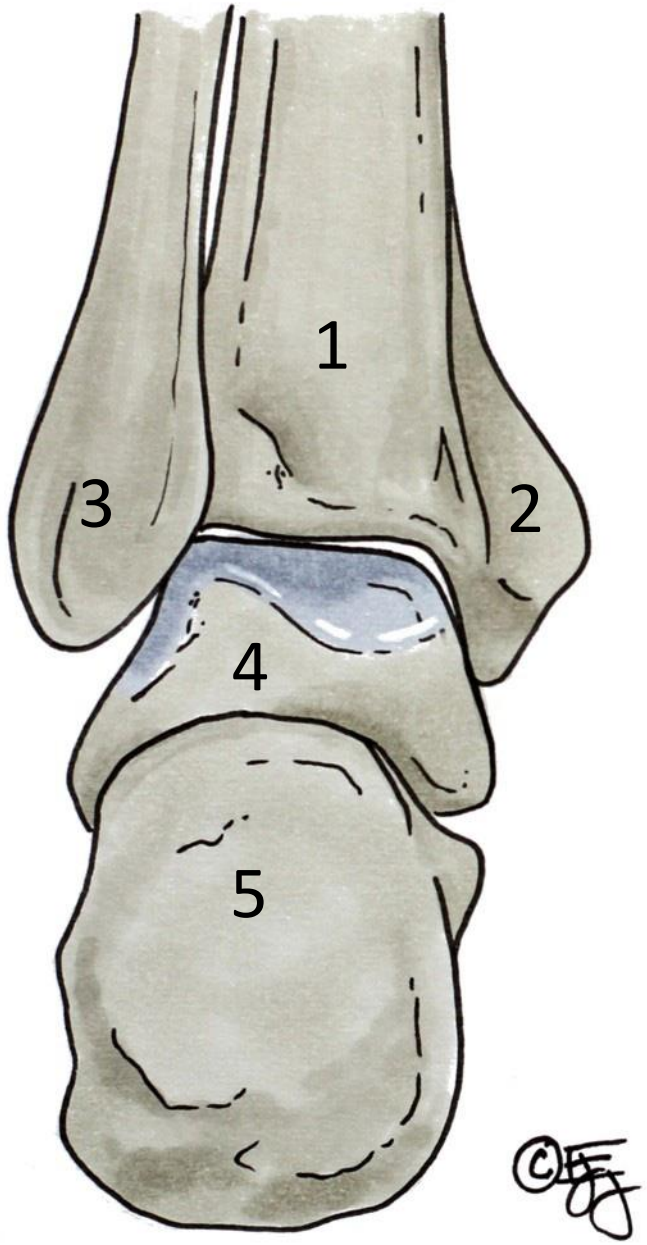
Ankle

- The ankle joint is composed of the fibula, tibia and talus.
- Also referred to as the tibiotalar joint or the talocrural joint
- A hinge joint that allows the foot to dorsiflex and plantarflex.
- Moves in all three planes; greatest ROM in sagittal plane.



Range of Motion

- Sagittal
  - 20˚ dorsiflexion - 50˚ plantarflexion
- Coronal
  - 23° inversion – 12° eversion
- There is also internal (during dorsiflexion) and external (during plantar flexion) axial rotation that occurs at the ankle.



Posterior View (left foot)

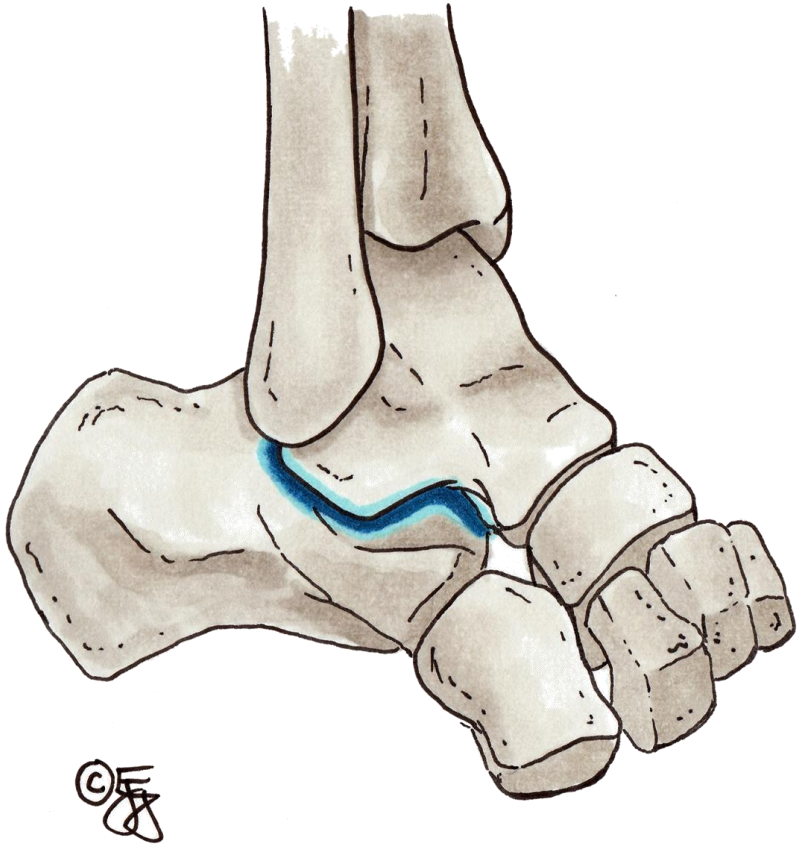
1. Tibia
2. Medial malleolus (tibia)
3. Lateral malleolus (fibula)
4. Talus
5. Calcaneus

Subtalar Joint

- The *subtalar joint* is between the talus and calcaneus.
- Aka the talocalcaneal joint.
- The movements that occur at the subtalar joint are gliding and rotation. The combination of these movements clinically are known as inversion and eversion; these are considered to be the primary movements in the subtalar joint
- Much of the motion in the hindfoot and midfoot either comes directly from the subtalar joint or is affected by it.

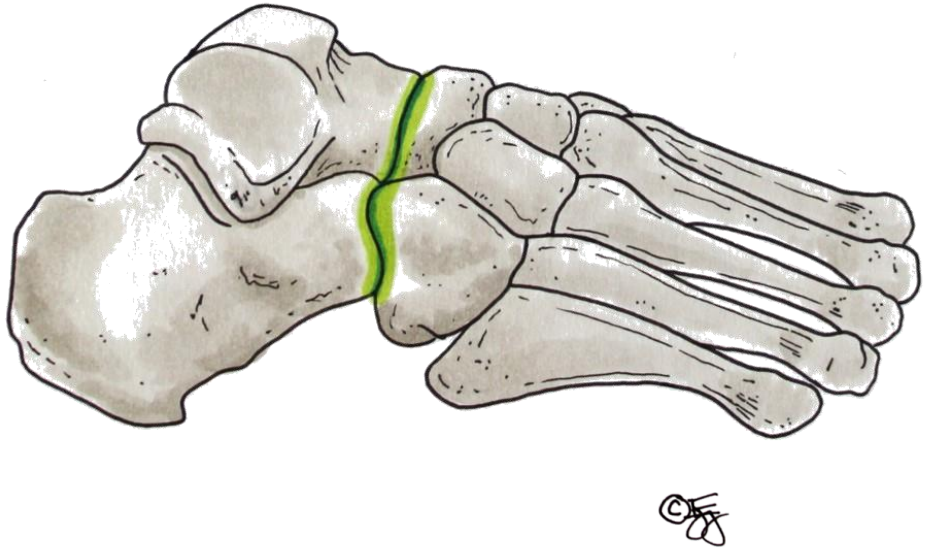
Range of Motion

- Coronal
  - 25°- 30° inversion - 5° - 10° eversion



Transverse Tarsal Joint

- aka *midtarsal joint* or *Chopart's joint*
- Compound joint comprised of two separate joints; the talonavicular joint and the calcaneocuboid joint. It is sometimes referred to as the TNCC joint complex.
- During weight bearing, the navicular and cuboid bones become fixed and immobile, permitting the talus and calcaneus to move in relation to them. Through these movements, the transverse tarsal joint facilitates foot inversion and eversion.
- Movement of the transverse tarsal joint is always mechanically linked with that of the subtalar joint.
- Motion at the transverse tarsal joint is supination and pronation (triplanar motion)

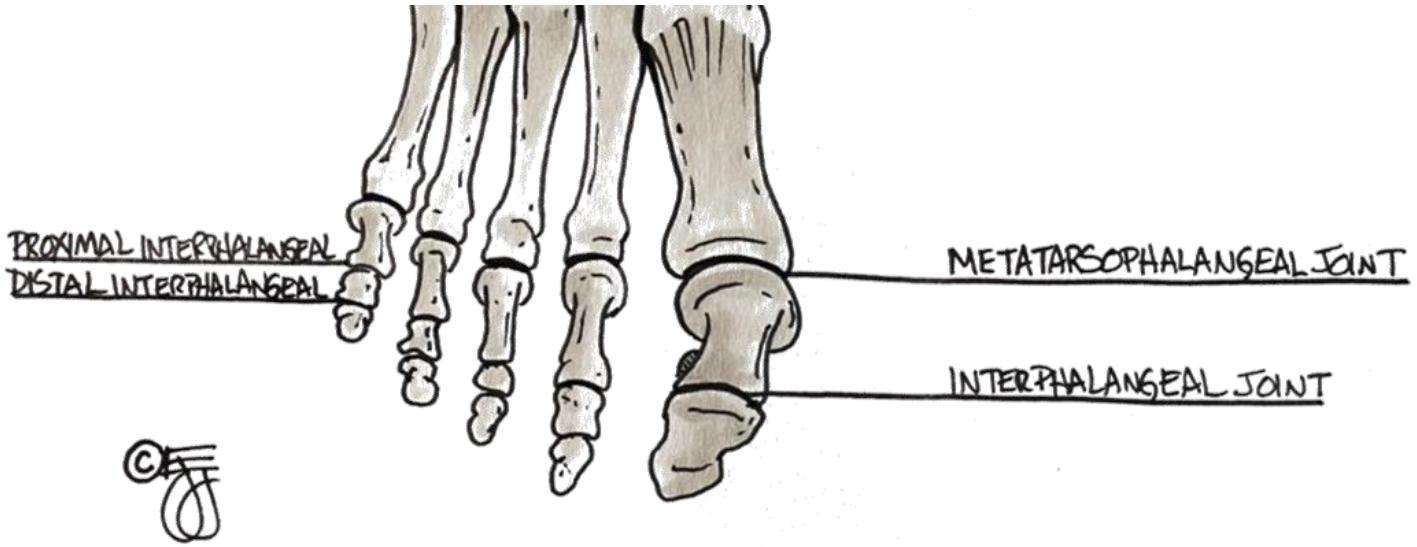


Tarsometatarsal Joint

- The tarsometatarsal, or *Lisfranc*, joint is the grouping of bones (compound joint) in the midfoot, where the five metatarsal bones meet with the cuboid bone and the three cuneiform bones.
- In the normal Lisfranc joint complex, the first three metatarsal bases articulate with their respective cuneiforms, and the lateral two metatarsals articulate with the cuboid. The second metatarsal base is tightly recessed in a mortise formed by the three cuneiform bones.
- The intertarsal ligaments, dorsal and plantar tarsometatarsal ligaments, and transverse ligaments provide soft tissue stability.
- The tarsometatarsal joint complex has very little motion and is critical in stabilizing the arch for push off during ambulation.

Metatarsophalangeal and Interphalangeal Joints

- The *metatarsophalangeal joint (MTP or MTPJ)* is between the metatarsals and the phalanges
- Hinge joints that allow mostly plantar and dorsiflexion and allow the toes to maintain contact with the ground during push off.
- First MTP ROM: 70˚ - 90˚ dorsiflexion, 35˚- 50˚ plantarflexion
- Lesser toes MTP ROM: 40˚ dorsiflexion, 40˚ plantarflexion
- The interphalangeal joints are found between the phalanges.



The End…