Universidad de Navarra

ANATOMY I
BONES & JOINTS
2016 - 2017

Come to the lecture having thoroughly read and understood these notes, with the complementary detailed reading of the textbook and atlas.

BIBLIOGRAPHY

Cunningham's textbook of anatomy. GJ Romanes ed. 1981
Gray's anatomy. S Standring ed. 2015

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10. INTRODUCTION TO THE BONES AND JOINTS

Axial skeleton: skull, vertebral column, ribs, sternum
Appendicular skeleton: bones of the upper and lower limbs

BONE

Concept
- Structure: composition (organic & inorganic). Mainly mineral (hydroxyapatite)
- Living tissue:
  - Development growth, definitive shape.
  - Metabolism. Cells: osteoblasts, osteoclasts, osteocytes.

Functions
- Supportive structures of the body
- Protects organs
- Dynamic: insertion of muscles, levers on which muscles act
- Movement
- Reservoir of calcium and phosphorus
- Hematopoietic
- Special: hearing, chewing

Internal conformation
- Compact
- Spongy (= trabecular, cancellous)

Marrow
- Red marrow formation of red and white blood cells
- Yellow marrow fat

External conformation
- Shape:
  - Long femur, tibia…
  - Short carpal, tarsal bones, sesamoids
  - Irregular vertebrae, skull bones
  - Pneumatic paranasal sinuses, mastoid cells
  - Plane scapula
- Regions or descriptive elements: faces, borders, ends
- Morphologic elements:

Surfaces	Prominences	Cavities
Base Head *Facet*: smooth, flat, for articulation	*Border*: *Condyle*: rounded articular area *Epicondyle*: eminence superior to a condyle *Crest*: ridge of bone *Line*: linear elevation *Malleolus*: rounded process *Protuberance*: projection of bone *Spine*: thornlike process *Spinous process*: projecting spinelike part *Trochanter*: large blunt elevation *Tubercle*: small raised eminence *Tuberosity*: large rounded elevation	*Foramen*: passage through a bone *Fossa*: hollow or depressed area *Groove*: elongated depression *Notch*: indentation at edge of a bone *Hiatus*: natural fissure in a structure

- Surface:
  - Fresh: cartilage, perichondrium, periosteum. ligaments, tendons, aponeurosis, intermuscular septa
  - Dry: smooth (cartilage) / slightly coarse (periosteum, vessels) / coarse (insertions)

- Periostium, 2 layers: osteogenic (deep), fibrous (superficial)

Vascularization (nutrient artery)

Innervation

Covered by cartilage in the joints, periosteum … in the remaining surface

Embriogenic origin: mesenchyme
- Intramembranous ossification:
- Chondral ossification: (ossification of a chondral mould) endochondral / perichondral

Centres of ossification
- Primary centres
- Secondary centres

Long bones: Epiphysis, physis, metaphysis, diaphysis, apophysis

CARTILAGE

Composition
- Water 70%
- Extracellular matrix: Collagen, proteoglycans, Glycoproteins
- Cells: chondrocytes

Main function:
- provide gliding surface to the bones (joints)
- growth of bones (physis)

Types of cartilage
- Hyaline: articular surfaces
- Elastic: external ear
- Fibrocartilage meniscus, intervertebral discs, glenoid labrum, pubic symphysis

Avascular

JOINTS

Types
- Solid: no cavity, components held together by connective tissue
- Synovial: elements separated by a cavity

SOLID JOINTS (synartrosis)

Bone (synostosis) sacrum

Fibrous (synfibrosis):
- Sutures skull periosteum & fibrous tissue (sutural lig) [plane, serrate, squamous, schindylesis]
- Gomphosis teeth peg into socket, fibrous suture
- Syndesmosis distal tibiofibular dense fibrous suture

Cartilaginous:
- Syncondrosis epiphysial cartilage, sternocostal
- Amphiartrosis pubis, IV lamina of hyaline cartilage + fibrocartilage = symphysis

SYNOVIAL JOINTS (diartrosis)

CLASSIFICATION

Shape of articular surface

- Flat (plana, artrodia)	one plane axis	gliding	carpo-metacarpal joint
- hinge (ginglymus, trochlea)	one transverse axis	flexion-extension	interphalangeal joint
- pivot (trochoidea)	one vertical axis	rotation	radioulnar, atlas-dens
- condylar (condyloid)	2 axis, no rotation in vertical axis		metacarpophalangeal
- Bicondylear	two axis (transverse, long)	F-E, rotation	knee, occipital-atlas
- saddle (sellaris)	Two axis		Trapezium-metacarpal joint
- ball and socket (spheroidea)	multiaxial (enarthrosis)		shoulder, hip

Movement:
- uniaxial
- biaxial
- multiaxial

COMPONENTS
- Articular cartilage, hyaline
- Synovial membrane (highly vascular, synovial fluid)
- Fibrous capsule (fibrous membrane) (ligaments)
- Bursae
- Fat pads
- Tendons
- Articular discs: meniscus (fibrocartilage) pubis, knee, ACJ, ECJ

MOVEMENTS

Abduction (away from the median plane)	Adduction
Flexion (bending)	Extension
Supination (palm goes anterior)	Pronation
Rotation (around an axis)	external / internal
Opposition	Reposition
Circumduction (circumferential)	

11. OSTEOLOGY OF THE SPINE. THE ATLAS AND AXIS

Curves of the spine: lordosis, kyphosis
Thoracic due the shape of the vertebrae, Cervical and lumbar due to the shape of the discs
Vertebrae: 7 Cervical + 12 thoracic + 5 lumbar + 5 sacral + 4/5 coccygeal

TYPICAL VERTEBRA

Body:
- intervertebral surface: *placa terminalis*
- *fovea vascularis*: perforations in the surface for embryonic vessels
- epiphyseal ring
- venous plexus under the *placa terminalis*

Arch: pedicles, lamina.
Vertebral foramen
Spinous process (*processus spinosus*)
Transverse process
Articular process (with its articular facet, *facies articularis*)
- Superior: posterior orientation
- Inferior: anterior orientation

Superior and inferior vertebral notch (*incisura vertebralis sup / inf*) → intervertebral foramina

INTERVERTEBRAL FORAMINA
Radicular nerves
Limits
- Superior: pedicle of upper vertebra
- Inferior: pedicle of lower vertebra
- Anterior: intervertebral disc
- Posterior: zygapophysial joint

CERVICAL

Small
Vertebral body:
- Short in height, square shaped
- Concave superiorly, convex inferiorly
- Uncinate process, articulates with the superior vertebral body (synovial)
- Inferior surface, bevelled off anteriorly

Vertebral foramen, triangular

Transverse process
- (vertebral artery): *foramen transversarium*
- Anterior tubercle (rib element)
- Costotransverse lamella (*sulcus nervi spinalis*)
- Posterior tubercle

Spinous process, bifid
1st (atlas) and 2nd (axis) have specialized morphology (see later)

Special features of C6
- Anterior tubercle of transverse process, large (carotid tubercle). Carotid artery just anterior

Special features of C7
- No *foramen transversarium*, may be small foramen for vein (not artery)
- Transverse process
  - Anterior tubercle, small / absent
  - Posterior tubercle, large
- Spine: non bifid, large: prominent

THORACIC

Articulated ribs (incorporated to the transverse process in the rest of the non-thoracic spine)
Vertebral body: two hemifacets: superior and inferior
Vertebral foramen: rounded, smaller
Spinous process, long, caudal direction, three sided, sloping
Vertebral foramen round (spinal cord)
Laminae, broad, overlapping (superior over the inferior)
Pedicle: joints with the body superiorly: deep inferior notch
Superior articular process flat, facing posteriorly
Inferior articular process, faces anteriorly, projects from the *laminae*
Transverse process, club, posterolateral direction, costal facet (articulation with tubercle of the rib)

Articulation with ribs, double
- Hemifacets of the vertebral body. The superior costal facet articulates with the head of its own rib
- Transverse costal facet of the transverse process

T1, T10 (T11) articulate completely with their own rib
T1 has uncinate process
T4 irregularity due to aortic artery
T11, T12 articulate only with the head of the rib (no transverse costal facet): *floating* ribs
T11 facet for head of the rib is superior
T12 facet for head of the rib on the pedicle. Inferior articular processes have lumbar features.

LUMBAR

Body: large (size increases from L1 to L5)
Laminae: separated
No facets for articulation with ribs (incorporated in the transverse process)
Transverse processes thin and long. Except L5 (iliolumbar ligaments). It is the rib element incorporated: *costiform process*.
Accessory process (true transverse process)
Mammillary process

SACRAL

Fused into the sacrum
Triangular,
- base: *promontorium*
- apex inferior

Vertebral foramen: sacral canal
Vertebral arch: missing in S5 (S4): sacral hiatus (sacral cornu)

Anterior surface: concave
- 4 pairs of anterior sacral foramina

Posterior surface convex, medial to lateral:
- Median sacral crest (spinous tubercle)
- Intermediate crest
- Posterior sacral foramina (4)
- Lateral crest
- Depression of interosseous sacro-iliac lig.

Lateral surface:
- auricular surface (for ilium)

Articulates with
- Laterally: pelvic bone (ilium)
- Inferiorly: coccyx
- Superiorly: L5

COCCYGEAL

3 – 4 vertebrae, fused
Coccygeal cornu

ATLAS AND AXIS

ATLAS

Lacks vertebral body (fuses with C2 to form the dens of C2) = no intervertebral disc C1-C2
Lateral masses connected by the anterior and posterior arch
- Tubercle for transverse ligament

Anterior arch
- Facet for dens (*facies articularis dentis*)
- Anterior tubercle

Lateral mass articulates
- above: condyle of occipital. Superior articular surface bean shaped, concave (glenoid cavity), antero-medial direction
- below: with the superior articular process of C2. Inferior articular surface circular and flat (artrodia): rotation

Posterior arch
- Groove for vertebral artery (*sulcus vertebralis*)
- Posterior tubercle

AXIS

Vertebral body: *dens*.
Dens:
- Anterior articular facet for articulation with the anterior arch of C1 (*facies articularis anterior dentis)*
- Posterior articular facet for articulation with the transverse ligament of the axis. (*facies articularis posterior dentis)*
- Circular supero-lateral surfaces for insertion of the *alar ligaments* (from occipital condyles to dens)

Transverse ligament of the atlas: holds the dens in position

ATLANTO OCCIPITAL JOINTS

Bicondylear, axis converge anteriorly
Synovial
Ellipsoid
Components: occipital condyles + superior articular facets of the atlas
Anterior atlanto-occipital membrane
Posterior atlanto-occipital membrane
Movements: flexion - extension

ATLANTO-AXIAL JOINTS

Lateral atlanto-axial joint

Synovial
Plane shape (arthrodia)
Accessory atlanto-axial ligament

Median atlanto-axial joint

Pivot joint: trochoid
Two synovial cavities:
- Dens & Atlas
- Dens & transverse ligament

Transverse ligament (1): passes behind the dens spanning tubercles on medial sides of the lateral masses of the Atlas.
- upward expansion (2) to anterior edge of foramen magnum
- downward expansion (3) to back of the body of the axis

1 + 2 + 3 = *cruciform ligament* of the atlas
Alar ligament: from each side of the apex of the dens to medial side of each occipital condyle.

Movement: rotation: combines rotation of the atlas centred on the dens and sliding of the plate lateral atlanto-axial joints.

12. LIGAMENTS OF THE SPINE AND THE INTERVERTEBRAL DISC. THE THORACIC CAGE

JOINTS BETWEEN VERTEBRAE

Two types of joints:

SYMPHYSIS
= intervertebral disc
Inserts to vertebral body by a thin plate of hyaline cartilage (vertebral end plate). In the aged it is calcified cartilage and bone.
The *epiphyseal ring* develops in the margin of this cartilage plate
Function: unite vertebrae, load transmission

Height
- increases from cephalic to caudal
- height relative to the body's height is maximal in the cervical vertebrae (more mobility)

Annulus fibrosus (ring)
- Concentric layers of fibres
- Internal are vertical, intermediate are oblique, and external horizontal
- Outer (fibrous lamellae). Inner layers are fibrocartilage
- External layers may have vessels
- Interestriation angle between fibres, varies depending on compression
- Function: compresses one vertebra against the other

Nucleus pulposus
- central
- Collagen II, few cells. Extracellular matrix 80% water
- hydration and metabolic exchange through the *fovea vascularis* of the terminal plate and vessels in the *anulus*.
- no arteries or nerves

Composition
- 80% water (decreases with age)
- Neutral mucopolysaccharids
- Acid mucopolysaccharids
- Non collagenous proteins

Physical properties (functions as a liquid):
- Liquids are incompressible: resists the compressive effect of the annulus fibrosus
- Liquids transmit pressure equally in all directions
- Liquids are maximally deformable: distributes loads deforming according to the load

SYNOVIAL JOINTS (Zygapophysial joints)
Articular capsule, thin and rigid. No specific ligaments
Orientation of articular line: cervical horizontal, thoracic oblique, Lumbar vertical
Innervated (source of pain in back pain)

LIGAMENTS

ANTERIOR LONGITUDINAL LIGAMENT (Ligamentum longitudinale anterius)
Runs over the anterior surfaces of the vertebral bodies.
Widens from cranial to caudal

POSTERIOR LONGITUDINAL LIGAMENT (Ligamentum longitudinale posterius)
On the back of the vertebral bodies (anterior wall of the vertebral canal)
Attached to the discs and epiphyseal plate. Separated from middle portion of vertebral body (basivertebral veins)
Proximally continues at C1 & C2 with the *Tectorial membrane*, to the occipital bone
Distally finishes in the posterior sacrococcygeal ligament

LIGAMENTA FLAVA
Span the spaces between the laminae of adjacent vertebrae.
The only elastic ligament in the body

SUPRASPINOUS LIGAMENT
C7 - Sacrum
Ligamentum nuchae (C7 - External occipital protuberance)

INTERSPINOUS LIGAMENTS

INTERTRANSVERSE LIGAMENTS

THORACIC CAGE

RIBS

12 ribs
All articulate with the vertebral column
Anteriorly
- 1 to 7 articulate with the sternum through the costal cartilage (synchondrosis)
- 8 to 10 articulate with the costal cartilages of the ribs above: false ribs
- 11 and 12 no anterior connection: floating ribs

Shape: curved

Posterior end articulates with the vertebral column
- Head
- Neck. Tubercle: Articular part / Non articular part

Angle

Shaft: thin, external and internal surfaces
- Superior margin rounded
- Interior margin sharp. *Costal groove*

Anterior end articulates with the sternum

RIB 1	Flat in horizontal plane: superior and inferior surfaces Head only one articular surface: for T1 *Scalene tubercle*, in the superior surface, - Anterior groove: subclavian vein - Posterior groove: subclavian artery
RIB 10	Head, single articular facet for T10
RIB 11	Head, single articular facet for T11 Short No articulation with transverse process
RIB 12	No articulation with transverse process

STERNUM

Manubrium + body + xiphoid process

MANUBRIUM
Superior surface: jugular (suprasternal) notch
Clavicular notch: articular surface for clavicle.
Projection for articulation with 1st rib
Lateral border, hemifacet at the lower end (articulation with 2nd costal cartilage)

BODY
Anterior surface: transverse ridges (fusion of *sternebrae*)
Lateral margin: articular facets for costal cartilages (*incisurae costales*):
- 1 hemifacet
- 4 complete
- 1 hemi

XIPHOID PROCESS
Variable shape
1 hemifacet

COSTOVERTEBRAL JOINTS

A typical rib articulates with
1. Bodies of adjacent vertebrae: joint with the head of the rib
2. Transverse process of its related vertebra: costotransverse joint

The ribs rotate around the longitudinal axes

JOINT WITH THE HEAD OF THE RIB

The two facets of the head of the rib articulate with
- Superior facet on the body of its own vertebra
- Inferior facet on the body of the vertebra above

Ligamentum capitis costae radiatum. Fascicles (3): superior body, intervertebral disc, inferior body
Two synovial compartments (*intraarticular ligament*: from the crest of the head to the intervertebral disc)
Single joint capsule

COSTOTRANSVERSE JOINT

Synovial
Tubercle of the rib and the transverse process
Ligaments
- Costotransverse ligament — from neck of the rib to transverse process). *Ligamentum costotransversarium*
- Lateral costotransverse ligament — from tubercle of the rib to transverse process of the same level
- Superior costotransverse ligament — from neck of the rib to the superior transverse process

Foramen costotransversarium: delimited by Sup CT lig. and neck of the rib. Exit of nerve.

STERNOCOSTAL JOINTS

Upper 7 costal cartilages to sternum
Ligaments
- Chondrosternal ligament
- Intraarticular sternocostal ligament
- *Ligamenta sternocostale radiata*, anterior (fusion of both sides → *membrana sterni*)

Rib I to sternum: fibrocartilaginous (not synovial)
Rib II – VII: Divided in two compartments by intraarticular ligament. Synovial, become obliterated in old age.

INTERCHONDRAL JOINTS

Between costal cartilages of adjacent ribs
VII to XI (± V and VI)
Synovial

MANUBRIOSTERNAL AND XIPHISTERNAL JOINTS

Symphyses
Sternal angle: reference of plane that passes through T4-T5 intervertebral disc:
- superior / inferior mediastinum,
- superior border of pericardium
- end of ascending aorta, beginning of the arch of the aorta
- bifurcation of the trachea
- superior to pulmonary trunk

INTERCOSTAL SPACES

Costal groove (inferior border of superior rib)
Intercostal artery + vein + nerve

FUNCTIONS OF THE THORAX

1. Protect
2. Elasticity
3. Dynamic: insertion for muscles
4. Haematopoiesis
5. Anatomical reference

FUNCTIONAL ANATOMY OF THE TRUNK

Functions:

1. Balance (centre of gravity along the centres of curvature)
2. Muscle insertion (transverse and spinous processes)
3. Load transmission (rigidity): through the bodies (static component, single)
4. Mobility: flexibility (double dynamic component: synovial joints)
5. Resistance to compression, increases with the number of curvatures (C^2+1)

Movements

Flexion, Extension, Lateral flexion, Rotation
Movement is determined by the shape of the joints

- Mainly cervical and lumbar
- Flexion depends on the disc
- Rotations are greater in the inflexion points of curvature

13. THE SHOULDER GIRDLE

SCAPULA

Triangular
Over 2nd – 7th ribs

Costal surface
Concave
- bone strip in the medial border, insertion of *serratus anterior*
- insertion for subscapularis (*subscapular fossa*)

Dorsal surface
- Spine of the scapula
- Supraspinous fossa: supraspinatus muscle
- Infraspinous fossa: infraspinatus muscle

Spine, insertion for the trapezius, continues with the acromion
Spinoglenoid notch, passage for nerve for the infraspinatus
Acromion: distally and inferior, insertion of coraco-acromial ligament. Posterior angle. Tuberosity.
Facet for the clavicle in the medial border

Lateral angle:
Glenoid fossa
- Pear shaped
- Anterior border slightly notched
- Labrum glenoidale: fibrous lip
- Cartilage thinner in the center, thicker at the rim
- Fibrous capsule attached to the rim of the cavity and labrum
- Supraglenoid tubercle: insertion of long head of the biceps
- Infraglenoid tubercle: long head of the triceps

Coracoid process:
- lateral margin of the upper surface is insertion for the *coraco-humeral* and *coraco-acromial* ligaments
- Tip: insertion for coracobraquialis and short head of the biceps
- Superior surface: insertion of coraco-clavicular ligaments (conoid tubercle and trapezoid line)
- Medial surface: insertion of *pectoralis minor*

Lateral border
- Insertion of teres minor
- Insertion of teres major

Inferior angle

Medial border:
Angulated at the medial end of the spine

Superior border
Scapular notch for *suprascapular* nerve. Superior transverse ligament (omohioid)

CLAVICLE

Medial 2/3 convex forwards, triangular section
Lateral 1/3 concave forwards, flat

Inferior surface
Irregular
Lateral: Trapezoid line, Conoid tubercle
Intermediate part: groove for *subclavius muscle* and *clavipectoral fascia*
Medial: Impression for *costoclavicular ligament*

Superior surface
Smooth
Anterior border, insertion of deltoid (lateral 1/3) and *pectoralis major* (medial 2/3)
Posterior border, insertion of trapezius in the lateral 1/3
Medial: insertion of clavicular head of *sternoclenomastoid*
Insertion of cervical fascia
Insertion of *sternohyoid*

Lateral end (acromial)
Oval articular fact for acromion
Capsule attached to the ridge of the margin of the facet

Medial end (sternal)
- inferior ¾ moves on the articular disc
- superior ¼ rough, attachment for the disc

HUMERUS

Proximal end

- Head of the humerus, articular surface, retroverted. Cartilage thicker at the centre, thinner at the rim
- Anatomical neck
- Surgical neck
- Greater tubercle (*tuberositas major)*, on the anterolateral side, insertion for supraspinatus, infraspinatus, teres minor
- Lesser tubercle (*tuberositas minus)*, anterior, for subscapularis
- *Intertubercular groove*: long head of the biceps tendon. Covered by the transverse ligament.
- Crest of the greater tubercle,
- Crest of the lesser tubercle, teres major
- *Latissimus dorsi* inserts on the floor of the Groove (anterior to teres major)

Body

Triangular
Medial border: Insertion of coracobraquialis
Lateral border continues with the lateral supracondylar ridge (insertion of *brachioradialis* and *extensor carpi radialis longus*)

- Deltoid tuberosity
- Groove for the radial nerve

Anterior surface, lower half, insertion of brachialis
Posterior surface: Spiral groove for the radial nerve

Lower end

Wide, flat, anteriorly angulated
Distal

- *Trochlea*: articulation with ulna
- *Capitulum*: articulation with head of the radius

Anterior:

- Coronoid fossa
- Radial fossa

Posterior: Olecranon fossa
Medial epicondyle
Lateral epicondyle

STERNOCLAVICULAR JOINT (cleidosternal)

Synovial
Components:
- proximal end of the clavicle: concave anteroposteriorly
- clavicular notch of the manubrium: concave vertically. Surface smaller than that of the clavicle

Articular surface
Saddle shaped (selaris)
Plane: oriented to the back, superior and lateral
Two compartments (articular disc)

Ligaments
- Anterior sternoclavicular ligament
- Posterior sternoclavicular ligament
- Interclavicular ligament (*interclaviculare)*
- Costoclavicular ligament, the most relevant
  - Anterior fibers, from the rib to the clavicle laterally oriented
  - Posterior fibers, from the rib to the clavicle, medially oriented

Movements
Translation / gliding in the AP and vertical plane
Rotation about the long axis of the clavicle, centred in the SCJ, revolution figure, 30º in all directions

Vascularization
Branches of internal thoracic artery
Branches of suprascapular artery

Innervation
Medial supraclavicular nerve
Nerve to the subclavius

ACROMIOCLAVICULAR JOINT

Synovial.
Components: acromion (oval facet on the medial surface) + clavicle (facet on acromial end)
Plane shape (arthrodia)

Ligaments
- Acromioclavicular ligament
- Coracoclavicular ligaments (the most relevant):
- Trapezoid: lateral (from base of coracoid to clavicle)
- Conoid: medial, triangular: base in clavicle, vertex in base of coracoid

Vascular supply
- Branches of the Suprascapular artery
- Branches of the thoraco-acromial arteries

Innervation
- Branches from suprascapular nerve
- Branches from lateral pectoral nerve

Movements
AP plane + Sagittal plane + rotation

SCAPULAR LIGAMENTS

- Superior transverse scapular ligament
- Inferior transverse scapular ligament: from lateral border of the scapular spine to back of the neck of the scapula
- Coracoacromial ligament

SCAPULOTHORACIC JOINT

Elevation – depression
Protraction – retraction
Lateral – medial rotation

GLENOHUMERAL JOINT

Synovial
Enarthrosis (ball and socket)
Composition: Humerus (head) + scapula (glenoid cavity)
Surfaces:
- humeral head, spherical
- glenoid cavity, small, expanded and deepened by glenoid labrum

Hyaline cartilage
Glenoid labrum: superiorly continuous with the biceps tendon

SYNOVIAL MEMBRANE

Loose inferior, anterior and posteriorly. Gets taught only at the end of range of motion.
Folds around the long head of the biceps tendon as it goes into the intertubercular sulcus (bicipital groove)
Protrudes through aperture in the fibrous membrane: bursae
- Subtendinous bursa of subscapularis
- Subacromial
- Subdeltoid

FIBROUS MEMBRANE

Redundant inferiorly

LIGAMENTS

- Superior glenohumeral ligament	superior region of glenoid rim	to	tuberositas major
- Middle glenohumeral ligament	superior region of glenoid rim	to	tuberositas minor
- Inferior glenohumeral ligament	inferior region of glenoid rim	to	tuberositas minor, neck of the humerus
- Coracohumeral ligament			
- Transverse humeral ligament			

JOINT STABILITY

Ligaments
Tendons: rotator cuff / collar
Skeletal arch (Acromion + coracoacromial ligament + coracoid process)
Tendon of the long head of the biceps

VASCULAR SUPPLY

- Anterior circumflex humeral artery
- Posterior circumflex humeral artery
- Suprascapular artery

INNERVATION

- Branches from the posterior cord
- Suprascapular nerve
- Axillary nerve
- Lateral pectoral nerve

MOVEMENTS

Flexion (50º-90º), with the STJ goes up to 180º	Extension 25º-50º
Adduction 30º (includes flexion)	Abduction (60º-80º) goes up to 140º with the STJ (1/3 STJ, 2/3 GHJ)
Internal / medial rotation 95º	External / lateral rotation 30º -80º
Circumduction	

14. THE ELBOW JOINT

ULNA

Upper end

Trochlear notch	fits on the trochlea of the humerus. Cartilage transversely divided. *Incisura trochlearis*
Olecranon	proximal end, insertion of Triceps and ligaments
Coronoid process	anterior, completes the articular notch, larger medial than lateral
Radial notch	lateral, for the head of the radius. Anular ligament attached to the anterior and posterior margin
Tuberosity of ulna	distal to coronoid process, for insertion of *braquialis*
Sublime tubercle	insertion of anterior part of ulnar collateral ligament
Triangular fossa	for origin of supinator
Supinator crest	limits posteriorly this fossa. Insertion of radial collateral ligament

Body

Triangular in section, tapers distally to be cylindrical

Interosseous border, lateral, attachment of interosseous membrane
Anterior border
Posterior border

Posterior surface proximally, insertion of *anconeus*

Lower end

Head
Styloid process projects distally from the posteromedial region of the head.
Posterior groove for the *extensor carpi ulnaris*

RADIUS

Head

Concave proximal surface, for articulation with *capitulum* of the humerus
Articular circumference, contacts with the radial notch of the ulna, and the annular ligament

Neck

Body

Proximally is cylindrical, distally is triangular
Medial convexity

Radial tuberosity for insertion of the *biceps* tendon. Anterior part is smooth, contacts with bursa. *Tuberositas radii*

Interosseous border distally split in the anterior and posterior ridges of the ulnar notch.
Anterior border
Posterior border

Lateral surface
Anterior surface proximal ¾ for flexor pollicis longus, distal ¼ for insertion of pronator quadratus
Posterior surface middle 1/3 insertion for *abductor pollicis longus* and *extensor pollicis brevis*

Distal end

Anterior surface
Lateral surface: Styloid process extends from the lateral part
Medial surface: ulnar notch. Lateral edge is for insertion of articular disc
Posterior surface: convex, dorsal radial tubercle. *Sulci musculorum extensorum*
Carpal surface
- Concave
- Divided in two parts by a ridge: lateral triangular for scaphoid, medial quadrilateral for lunate.

The **extensor tendons** pass over the distal end of the radius and ulna along **six grooves**, from lateral to dorsal:

1	*Abductor pollicis longus* *Extensor pollicis brevis*	Lateral surface of radius The *braquirradialis* inserts along this grove, forming its floor
2	*Extensor carpi radialis longus* *Extensor carpi radialis brevis*	Dorsolateral radius
3	*Extensor pollicis longus*	2 and 3 are separated by the dorsal radial tubercle, point of inflexion Dorsal radius
4	*Extensor digitorum*	Dorsal radius
5	*Extensor digiti minimi*	Between radius and ulna
6	*Extensor carpi ulnaris*	Dorsal groove on the ulnar head

THE ELBOW JOINT

Composition: Humerus + Radius + Ulna
Hyaline cartilage

Type	*Surface*	*Movement*
Condylar	Radius (head) + Humerus (*Capitelum*)	Flexion-extension, Spinning (prono-supination)
Trochlea	Ulna (trochlear notch) + Humerus (trochlea)	Flexion-extension
Trochoid	Radius (head) + Ulna (radial notch)	Pronation-supination

ARTICULAR SURFACES

Humero-ulnar:
- Humerus trochlea angled forward
- Ulna: medial surface is bigger, canal has spiral orientation

Humero-radial
- Humerus Hemispheric condyle (capitulum)
- Radius shallow concavity

SYNOVIAL MEMBRANE

Single synovial membrane for all these joints
Overhangs the limits of articular cartilage
Origin: edges of the articular cartilage
Lines radial fossa, coronal fossa, olecranon fossa, deep surface of joint capsule, medial surface of trochlea
Includes 1 cm of the neck of the radius
Separated from fibrous membrane by fat pads in coronoid, radial and olecranon fossa
Sacciform recess around the radial head

FIBROUS MEMBRANE

Inserts in the interosseous border of ulna and radius
From the radius goes distally to the ulna (prevents the radius going proximally)

LIGAMENTS

Radial collateral ligament: from epicondyle to ulna (supinator crest)
Medial collateral ligament:
- Anteriorfrom epitrochlea to ulna (*tuberculus sublimis*). Biomechanically relevant
- Posterior
- Transverse

Anular ligament of the radius, articular ligament. From anterior to posterior borders of the radial notch of the ulna
Quadrate ligament (*ligamentum quadratum).* From inferior border of radial notch to medial surface of the neck of the radius.

VASCULARIZATION

Anastomotic network

INNERVATION

Branches of radial nerve
Musculocutaneous nerve

MOVEMENTS

Flexion
Extension

PROXIMAL RADIOULNAR JOINT

Annular ligament of the radius: from anterior border of radial fossa, around the radial head, to posterior border of radial fossa.
Quadrate ligament

RADIOULNAR SYNDESMOSIS

Connection between shafts of radius and ulna
- Interosseous membrane
- Oblique cord

DISTAL RADIOULNAR JOINT

Composition: head of the ulna (*circumferentia ulnaris),* ulnar notch of the radius
Trochoid
Single axis with the proximal radioulnar joint, both move synchronically
Articular disc: from the base of the styloid to the medial margin of the carpal articular surface of the radius
Ligaments: radioulnar, palmar and dorsal
Recessus sacciformis, between radius and ulna, extends proximally.
Movement: prono-supination, 180º

15. JOINTS AND LIGAMENTS OF THE WRIST

CARPUS

Eight bones
Proximal row (radial to ulnar): scaphoid, lunate, triquetrum, pisiform.
Distal row (radial to ulnar): trapezium, trapezoid, capitate, hamate.
Dorsal carpal surface is convex, …as a general rule the dorsal surface of the bones is wider than the palmar
Palmar concavity deepened
- ulnarly by the hook of the hamate and the pisiform,
- radially by the tubercle of the scaphoid and the trapezium

The concavity is made a tunnel by the *flexor retinaculum*: flexor tendons and median nerve (not the ulnar nerve!)

SCAHPOID
Long axis directed distal, radial and palmar
Tubercle in the distolateral part, attachment for flexor retinaculum
Crossed by the *flexor carpi radialis*
Dorsal surface: rough, foramina in the distal half
42% articular surfaces
- Radial surface convex
- Lunate surface flat, semilunar
- Capitate surface large, concave
- Trapezium & trapezoid continuous, convex, distal

LUNATE
Semilunar shape

TRIQUETRUM

PISIFORM

TRAPEZIUM
Double curved articular surface for the 1st metacarpal (sellar joint)

TRAPEZOID

CAPITATE
Proximal head
Dorsal surface: broad
Palmar surface: prominence for insertion of *ligamentum carpi radiatum*: fibres to all the bones of the carpum (except pisiform)
Distal surface: three articular facets for 2nd, 3rd and 4th metacarpals
Manages the movement of the rest of the bones

HAMATE
Palmar surface: palmar hook (*hamulus*)
Lateral facet for the capitate, flat
Medial facet for the triquetrum, sinuous
Distal surface: facets for the base of the 4th and 5th metacarpals

METACARPUS

Base lateral articular surfaces for the neighbouring metacarpal (intermetacarpal joint). Lateral tubercle for insertion of lig.
Body
Head condylar surface

FIRST METACARPAL
Base has double curve (sellar joint)

SECOND METACARPAL

THIRD METACARPAL
The longest, longitudinal axis of the hand

FOURTH METACARPAL

FIFTH METACARPAL

RADIOCARPAL JOINT

Synovial

Articular surfaces

- Proximal: radius (divided by low ridge) & ulna (articular disc)
- Distal: scaphoid, lunate, triquetrum

Condylar joint
Glenoid cavity formed by the carpal surface of the radius & articular disc

Fibrous capsule

Ligaments

Radiocarpal ligament palmar	Radioscaphocapitate Long radiolunate Radioscapholunate Short radiolunate
Ulnocarpal ligament palmar	Ulnolunate Ulnotriquetral Ulnocapitate
Radiocarpal ligament dorsal	Radiolunotriquetral ligmament
Ulnocarpal ligament dorsal	

Radial carpal collateral ligament	to scaphoid tubercle, trapezium, metacarpal
Ulnar carpal collateral ligament	to pisiform, hook of the hamate, base of the 5th metacarpal

Flexor retinaculum

Vascularization

- Anterior interosseous artery
- Posterior interosseous artery
- Deep palmar arch

Innervation

- Median nerve
- Ulnar nerve
- Radial nerve
- Dorsal cutaneous branch of the ulnar nerve

Movements

Condylar joint, biaxial
Flexion, extension, adduction, abduction, circumduction

INTERCARPAL JOINT

JOINTS OF THE PROXIMAL CARPAL ROW

Two arthrodial: scapholunate, triquetrolunate

Ligaments

- Palmar intercarpal ligaments
- Dorsal intercarpal ligaments
- Interosseous ligament — the ligaments are mainly proximal

Vascularization

- Deep palmar arch
- Dorsal arch

Innervation

same as radiocarpal joint

JOINTS OF THE DISTAL CARPAL ROW

The interosseous ligaments are mainly distal

MIDCARPAL JOINT

Irregular line, double curve, between the proximal and distal row
Common articular space with the intercarpal joints in the proximal and distal row
Sellar joint, Dart throwing motion

JOINT OF THE PISIFORM

Arthrodia
Joint capsule separate from the rest of the carpus
Ligaments:

- Pisohamate
- Pisometacarpal
- Fascicles of the ulnocarpal medial collateral ligament

15. JOINTS AND LIGAMENTS OF THE HAND

PHALANGES

14, 3 per finger, 2 in the thumb
Base, shaft, head
Shaft tapers distally
Dorsal surface transversely convex
Palmar surface transversely flat, concave anteriorly in its long axis
Bases: lateral tubercles for insertion of ligaments
- Proximal phalanges: concave oval facets
- Middle and distal: smooth middle ridge
  Heads of proximal and middle is trochlear
  Heads of the distal phalanges are non-articular, palmar tuberosity (insertion of *flexor digitorum profundus*)

COMMON CARPOMETACARPAL JOINTS

Irregular, arthrodia

- 2nd metacarpal: trapezium, trapezoid and capitate
- 3rd metacarpal: capitate
- 4th metacarpal: capitate and hamate
- 5th metacarpal: hamate (flattened saddle)

Interosseous ligament, distal to the intermetacarpal joint surfaces
Palmar and dorsal carpometacarpal ligaments e.g. from the base of the 3rd to the trapezoid, capitate and hamate
Very limited movement (most of all 5th metacarpal)

THUMB CARPOMETACARPAL JOINT

Highly mobile
Trapezium & base of the first metacarpal
Synovial
Saddle
Ligaments: palmar, lateral (triangular), dorsal
Some fibres of the radial collateral ligament reach the base of the M1
Movements: flexion, extension, abduction, adduction, opposition (medial rotation + flexion + adduction)

INTERMETACARPAL JOINTS

Arthrodia: Reciprocal articulation at the base from 2nd to 5th metacarpal
At the diaphysis is the interosseous metacarpal space.
Distally to the articular surfaces there is a syndesmosis (interosseous metacarpal ligament)

Ligaments
- Dorsal metacarpal ligament
- Palmar metacarpal ligament
- Interosseous metacarpal ligament
  Deep transverse metacarpal ligament, span the heads of the 4 medial metacarpals

METACARPOPHALANGEAL JOINTS

Synovial
Condylar
Composition: head of metacarpal & base of proximal phalanx
Ligaments:
- Collateral ligament: from tubercle at each side of the metacarpal head to the base of the phalanx
- Palmar ligament, fibrocartilage (slides under the head), loose insertion proximally, firm fixation distally,
- *Transverse metacarpal ligament*, joins the 2nd to 5th radius palmar ligaments

Thumb: sesamoid bones
Movements:
- flexion, extension, adduction, abduction, rotation
- Insertion of ligaments is not in the axis of the condyle, tightens in flexion, in extension loosens and allows ab/adduction

INTERPHALANGEAL JOINTS

Trochlea
Collateral ligaments: from head of proximal phalanx to base of distal phalanx
Palmar ligament
Flexion and extension
Ligaments
- Collateral ligaments
- Palmar ligament, fibrocartilage

In the thumb there are sesamoid bones
Movements: flexion, extension

16. THE PELVIS. THE HIP JOINT

COMPOSITION
Pelvis = coxal + sacrum
Hip bone (coxal) = ilium + pubis + ischium

Greater pelvis — separated by plane formed by the *linea terminalis* and *promontorium*
Lesser pelvis

Línea terminalis (innominate): Arcuate line + Ileopectineal line + Pecten pubis

Superior aperture (pelvis inlet)
Inferior aperture (pelvis outlet)

MEASUREMENTS	from	to	
Greater pelvis			
- Intercrestal	both outer lips of the iliac crest		
- Interspinous	both ASIS		
- External anteroposterior	spine of S1	anterior margin of pubic symphysis	
Lesser pelvis			
- Superior aperture			
- AP anatomic	Promontorium	anterior margin of pubis	11,5
- AP, true, obstetric	Promontorium	middle part of pelvic surface of symphysis	11
- AP, conjugate diagonal	promontorium	inferior border of symphysis	
- Transverse			
- Oblique	SIJ	iliopubic eminence opposite	
- Cavity			
- Anteroposterior	centre of sacrum	middle of pelvic surface of symphysis	
- Transverse			
- Oblique	posterior end of SIJ	centre of obturator membrane opposite	
- Inferior aperture			
- AP (*conjugata vera*)	tip of coccyx	posterior lower margin of symphysis	
- Transverse	both ischial tuberosities		
- Oblique			

The diameters cross at one point at the centre of the aperture
The centres of the apertures and cavity conform the axis of the pelvis

FUNCTIONS
1. Basement of the inferior limb
2. Weight transmission to the inferior limb
3. Containment and protection of viscera
4. Birth canal
5. Muscle insertion
6. Balance, walk

ILIAC BORDERS

Iliac crest

- External lip — *Obliquus internus*
  - *Tubercle of the iliac crest*
- Intermediate line — *Transversus abdominis*
- Internal lip — *Obliquus internus*

Iliac tuberosity: thickening of the posterior portion

Anterior Superior iliac spine (ASIS) — Sartorius, Inguinal ligament
Posterior Superior Iliac spine (PSIS)

Anterior border

Anterior inferior iliac spine: *Rectus femoris*

Posterior border

Posterior inferior iliac spine
Greater sciatic notch

SURFACES

POSTEROLATERAL SURFACE (gluteal)

Limits:

- Iliac crest
- Superior border of the acetabulum
- Anterior border
- Posterior border

Three lines:

- Inferior gluteal line: AIIS → Posterior border of acetabulum
- Anterior gluteal line: ASIS → Superior border of greater sciatic notch
- Posterior gluteal line: Iliac crest → PIIS

Supra-acetabular sulcus: insertion of reflected head of rectus femoris.

MEDIAL SURFACE

Iliac fossa
Sacropelvic surface

- *Auricular surface* for the SIJ
- *Porción pélvica*: forma parte de la pared ósea de la pelvis menor. *Preauricular sulcus.*

Iliac tuberosity: between the auricular surface and posterior part of the crest

Arcuate line: separated iliac fossa from lesser pelvis, continuous with *pecten pubis*, to form the iliopubic part of *linea terminalis*.

ISCHIUM

Parts:
- Body
- Ramus

BODY
1. Femoral surface
2. Posterolateral surface
3. Pelvic surface

RAMUS
- Posterior surface
- Anterior surface

ISCHIAL TUBEROSITY
Ischial spine

Superior area
- Medial: Semitendinous + long head of the bíceps
- Lateral area: Semimembranous

Inferior area
- Medial area bursa
- Lateral area *Adductor magnus*

Acetabulum
- *Margo acetabularis*
- Supraacetabular sulcus
- Acetabular notch
- Acetabular ligament
- Acetabular fossa
- Lunate surface
- Labrum (*limbus)*
- Ligament of the head of the femur: inserts in transverse ligament, borders of the notch, borders of the fossa

Obturator foramen
- Obturator groove: obturator nerve and vessels
- Anterior obturator tubercle
- Posterior obturator tubercle

PUBIS

Body
- *Anterior surface*
- *Posterior surface*
- *Symphysial surface*, insertion of the fibrocartilaginous interpubic disc
- Anterior border, *pubic crest*, lateral end projects as the pubic tubercle (insertion of inguinal ligament)

Superior ramus
3 surfaces, 3 borders
- Pelvic surface
  - Pecten pubis: from the pubic tubercle to the iliopubic eminence
- *Pectineal surface* (anterior): limits
  - Anterior *Obturator crest*
  - Posterior *Pectineal line (pectin pubis)*
- Obturator surface, limits
  - Anterior obturator crest
  - Posterior inferior border

Inferior ramus
1. *Anteroexternal surface*
2. *Posterointernal surface*
3. *External surface*
4. *Internal surface*

FEMUR

Upper end

Head
2/3 sphere (actually is ovoid)
Fovea capitis femoris, in the postero-inferior quadrant of the articular surface, insertion for the ligament of the head

Neck
Infero-lateral direction
Cervico-diaphyseal angle 125º
- coxa vara: under average (varo, aro)
- coxa valga: over average

Declination angle (anteversion)

Anterior surface
- grooved and perforated for vessels
- Covered by synovial membrane down to the intertrochanteric line
- Intertrochanteric line, insertion for ligaments

Posterior surface
- groove of the obturator externus
- Intertrochanteric crest. Quadrate tubercle (for quadratus femoris)
- Only the medial half is covered by the synovial membrane

Greater trochanter

Medial surface	trochanteric fossa, for *obturator externus* tendon. The obturator internus inserts medially
Superior border	insertion for Piriformis and *Gluteus medius*
Anterior surface	Insertion of *gluteus minimus*

Lesser trochanter
Posteromedial
Insertion of psoas

LUMBROSACRAL JOINT

Iliolumbar ligament**:** 5th transverse process → iliac crest

SACROCOCCYGEAL JOINT

Anterior sacrococcygeal ligament
Posterior sacrococcygeal ligament

SACROILIAC JOINT

Synovial

Articular surfaces
Components: auricular surfaces of sacrum and ilium
Plane with irregularities
Cartilage is thick

Proper ligaments
- Anterior sacro-iliac ligament
- Interosseous sacro-iliac ligament
- Posterior sacro-iliac ligament

Accessory ligaments
- Sacrospinous ligament
- Sacrotuberous ligament covers the dorsal surface of the sacrum (except the foramina)
  Falciform process: the sacrotuberous ligament expands along the ischial ramus, whose concave edge blends with the fascial sheath of the internal pundendal vessels and pudendal nerve.

Sciatic foramina
- Greater sciatic foramen leads from the lesser pelvis into the gluteal region
- Lesser sciatic foramen leads from gluteal region into perineum

Movements:
- Nutation: when standing up, coccix goes backwards, promontorium goes anterior
- Counter-nutation

During pregnancy the pelvic ligaments loosen under the influence of the hormone *relaxin*

PUBIC SYMPHYSIS

Articulating surfaces: Reciprocal crests and papillae
Interpubic disc
- Hyaline cartilage covering the bone
- Fibrocartilaginous lamina, connects both cartilages (may have a cavity, due to absortion. It is not a synovial joint)

Superior ligament
Inferior ligament (arquate)

OBTURATOR MEMBRANE

THE HIP

CLASSIFICATION
Synovial
Ball and socket, multiaxial

FUNCTION
- Stability
- Weight bearing

MOVEMENTS
- Flexion, extension
- Abduction, adduction
- Rotation, medial (internal) & lateral (external)
- Circumduction

Passive range of motion is wider than active

ARTICULAR SURFACES
- Head of the femur
- Lunate surface of the acetabulum

Acetabulum covers 90% of the femoral head
Non articular acetabular fossa: insertion of *ligamentum teres*
Fovea of the femoral head: insertion of *ligamentum teres*
Acetabular labrum (*limbus acetabulare*): widens contact surface

SINOVIAL MEMBRANE
Medially inserts 0,5 away form *margo acetabularis*
Lines the *ligamentum teres*, acetabular fossa
Reflected upwards on the neck (intracapsular part of the neck of the femur): *Retinacula*: vascular plexus for the femoral head

FIBROUS MEMBRANE
Thick
Fibres in different directions
- Arciform — both insertions in the same bone
- Transverse — femur to coxal
- Arquate — femur to coxal, oblique
- Orbicular — deep, circular, no bony insertion, at the narrow (middle) region of the fibrous membrane

LIGAMENTS
Intracapsular
- Transverse acetabular ligament — spans the borders of the acetabular notch
- Ligament of the head of the femur (ligamentum teres), with branch of the obturator artery. Inserts at the border of the acetabular fossa and the transverse ligament.

Capsular
Spiral orientation: these ligaments tighten with the hip extension (standing), further stabilizing the joint.

1.	Iliofemoral ligament	anterior, shape of inverted Y	
	- External fascicle, transverse	anterior iliac spine	intertrochanteric line
	- Internal fascicle, descending		lesser trochanter
2.	Pubofemoral ligament anterior (weakest)	iliopectineal crest, pectin pubis	intertrochanteric line
3.	Ischiofemoral ligament posterior,		intertrochanteric line (not crest)

BURSAE
- Iliopsoas
- Obturator externus
- Obturator internus
- Quadratus femoris
- Gluteus maximus, medius, minimus

VASCULAR SUPPLY
- Branches of the obturator artery
- Medial circumflex femoral artery
- Lateral circumflex femoral artery
- Superior gluteal artery
- Inferior gluteal artery
- First perforating branch of the deep artery of the thigh

INNERVATION
- Femoral nerve
- Obturator nerve
- Superior gluteal nerve
- Nerve to the Quadratus femoris

17. THE KNEE JOINT

DISTAL FEMUR

Two condyles
Condyles anteriorly are confluent, continuous with the shaft
Posteriorly separated by the *intercondylar fossa*, project beyond the popliteal surface

Patellar surface
Extends proximally, specially in the lateral condyle
Transversely concave

Tibial surface
Divided by the intercondylar surface, anteriorly continuous with the patellar surface
Convex in all directions
Both have similar AP curvatures

Intercondylar fossa
Separates both condyles distally and posteriorly
Intracapsular but extrasynovial
Lateral wall, posterosuperior impression for insertion of the *anterior cruciate ligament* (ACL)
Medial wall, anterior impression for insertion of *posterior cruciate ligament* (PCL)

Lateral condyle
Larger anteroposteriorly than the medial
Lateral epicondyle, insertion of *fibular collateral ligament*
Groove for *tendon popliteus*, between epicondyle and articular surface (deep to FCL),
Tendon popliteus inserts inferior and anterior to FCL (pit for the popliteus)

Medial condyle
Adductor tubercle (*adductor magnus*)
Medial epicondyle, anteroinferior to the tubercle, *tibial collateral ligament*
Projects distally (bycondylar plane is horizontal, diaphyseal axis has 97º lateral angulation, not 90º)

PROXIMAL TIBIA

Two condyles
Superior
- Articular surfaces (tibial plateau)
- Intercondylar area, non articular

Lateral
- Fibular articular facet, faces distally and posterolaterally
- Interosseous border: margin for the attachment of the deep fascia
- *Gerdy's tubercle*, distal attachment of the iliotibial tract

Anterior: tibial tuberosity
Posterior: smooth

PATELLA

Largest sesamoid
Flat, distally tapered
Embedded in the tendon of the *quadriceps femoris*
Anterior surface, perforated by vessels
Posterior surface, articular, vertical ridge which fits in the intercondylar groove
- medial and lateral facets (lateral is larger)
- odd facet: narrow strip at the medial border
- apex, distally, rough surface for insertion of the patellar tendon. Separated from articular surface by infrapatellar fat pad

Superior border, thick, slopes anteroinferiorly
Medial and lateral border are thinner, converge distally at the apex

FABELLA

Small posterolateral sesamoid (biceps tendon)

The knee has three joints:
1. Tibiofemoral (bycondylear)
2. Patellofemoral (trochlea)
3. Proximal tibiofibular

1 & 2 are in the same articular space.

TIBIOFEMORAL JOINT

ARTICULAR SURFACES

Single articular cavity

Femoral surface

Two femoral condyles: greater curvature in distal surface, smaller curvature in posterior surface
Lateral condyle: longer, narrow (more in the centre)
Medial condyle: shorter, more round

Proximal tibial surface

Medial (concave) and lateral (convex) articular surfaces
Superior aspect of the tibial condyles: V shaped
Posterior tilt relative to the long axis of the shaft
Medial articular surface: oval, longer than the medial
Lateral tibial condyle overhangs the shaft of the tibia. Articular surface circular

Tibial intercondylar area

Narrowest centrally
Intercondylar eminence projects proximally as lateral and medial *intercondylar tubercles*
From anterior to posterior, insertion of
- anterior horn of medial meniscus
- anterior cruciate ligament
- anterior horn of lateral meniscus
- posterior horn of lateral meniscus
- posterior horn of medial meniscus
- posterior cruciate ligament

MENISCI

Fibrocartilaginous. Fibrous (vascularized) at the peripheral insertion, cartilaginous at the internal rim.
Attached at each end to facets in the intercondylar region of the *tibial plateau*
Borders are not parallel: the meniscus tapers in width as they go anterior (wider posterior that anterior)
Medial attached around to the capsule (*coronary ligament*) and tibial collateral ligament, C shape,
Lateral unattached to the capsule (*popliteal tendon*), O shape, wider ***c**itrô**e**n*
Functions: adjustment of articular surfaces, lubrication of surfaces
Internal meniscus has less ability to slide
Interconnected:
- anterior transverse ligament of the knee (present in 60%)
- posterior transverse ligament of the knee (present in 20%)

Connected posteriorly to the femur:
- Ligamentum meniscofemoralis anterius
- Ligamentum meniscofemoralis posterius

SYNOVIAL MEMBRANE,

Attached to the margins of the articular surfaces of the superior and inferior outer margins of the menisci.
Cruciate ligaments: are outside the articular cavity but enclosed within the fibrous membrane of the knee joint.

PLICAE

Alar fold (*plicae*), converge posteriorly in the infrapatellar fold (*adipose ligament*), which goes into the intercondylar fossa.
They limit the articular volume, producing invaginations of the synovial membrane adapting the shape of the synovial membrane to the contour of the bones. Volume of synovial liquid is approximately 1,5 cm^3
Subpopliteal recess posterior to the lateral meniscus, related to the popliteal tendon

FAT PADS

Infrapatellar fat pad

FIBROUS MEMBRANE

Capsule and retinacula

Medial:	blends with the tibial collateral ligament, attached on its internal surface to the medial meniscus
Lateral:	the external surface is separated by a space from the fibular collateral ligament the internal surface of the fibrous membrane is not attached to the lateral meniscus
Anteriorly:	medial and lateral patellar retinacula, attached to the margins of the patella, reinforced with tendinous expansions from the vastus lateralis and vastus medialis muscles
Posterior:	Fibres go vertical. *Oblique popliteal ligament:* thickening, extension from the tendon of Semimembranous

Medial soft tissues

Layer 1, Sartorius, medial patellofemoral ligament, patellotibial ligament
Tendons of gracilis and semitendinous
Layer 2: superficial part of MCL
Layer 3: capsule of the knee. Posteriorly blends with layer 2 to form the conjoined posteromedial capsule

Lateral soft tissues

Superficial:	lateral patellar retinaculum (from patella to iliotibial band)
Middle:	fibular collateral ligament, popliteofibular ligament, fabellofibular ligament, arquate lig., Anterolateral lig.
Deep:	lateral part of the capsule

BURSAE
- Suprapatellar
- Patellar, deep and superficial
- Gastrocnemius (posterior to the femoral condyles)
- Tendons: Popliteus, Biceps, Sartorius, Gracilis, Semimembranosus

LIGAMENTS

Patellar ligament
Continuation of the quadriceps muscle
Inferior margin and apex of the patella → tibial tuberosity
Plica synovialis infrapatellaris

Tibial (medial) ligament
Wide, but thin
Attached to the fibrous membrane
Medial femoral epicondyle, inferior to adductor tubercle → medial margin of medial surface of tibia above and behind the attachment of the S-G-St
Isolated lesion of MCL produces increase in external rotation of the tibia, not internal rotation (limited by cruciate ligaments)

Fibular (lateral) ligament
Cord-like
Above the groove of the popliteus tendon
Interiorly attached to a depression of the lateral surface of the fibular head
Separated from the fibrous membrane by a bursa

Anterior cruciate ligament
In the intercondylar region
Anterior facet of anterior part of intercondylar area → ascends posteriorly to back of lateral wall of intercondylar fossa
Prevents anterior displacement of the tibia relative to the femur
38 mm x 11mm
Rupture produces the anterior drawer sign: the tibia over-slides anteriorly

Posterior cruciate ligament
From Posterior aspect of the intercondylar area → medial wall of the intercondylar fossa
Prevents posterior displacement of the tibia relative to the femur
38 mm x 13mm
Rupture produces the posterior drawer sign: the tibia over-slides posteriorly

VASCULAR SUPPLY
- Descending and genicular branches from the femoral, popliteal, lateral circumflex arteries
- Circumflex fibular artery
- Recurrent branches from the anterior tibial artery along the leg

INNERVATION
- Obturator nerve
- Femoral nerve
- Tibial nerve
- Common fibular nerve

MOVEMENTS

Flexion
Active 130º, passive 160º
Menisci move with condyles: the contour reduces (contact surface of posterior condyle is smaller, because it is more round)
Slide backwards (internal 6 mm, lateral 12 mm)
This sliding is limited by the *coronary ligament*, mainly in the internal meniscus
The medial condyle is 1,5 larger than the lateral: Flexion implies external rotation of the tibia (20º)
Untwisting of cruciate ligaments
The patella translates slightly anteroposteriorly
The crossing point of the cruciate ligament, in the sagittal plane goes cephalad

Extension
10º
The menisci get the wider contour
Anterior sliding of menisci, mainly the external meniscus due to the popliteal tendon
The twisting of the cruciate ligaments increases: stabilizes the knee, preventing lateral movements
Implies external rotation of the tibia, because the length of the medial condyle is larger that that of the lateral

Rotation
Possible in flexion
Vertical axis through the intercondylar tubercle
Lateral (external of the femur): PCL tightens, ACL loosens. MCL tightens, pressure on anterior area of internal meniscus
Medial (internal of the femur): PCL loosens, ACL tightens, LCL tightens, pressure on posterior area of internal meniscus

Anterior / posterior translation
Very limited by the cruciate ligaments

Medial / lateral shift (translation)
Very limited by the ligaments.

18. TIBIOPERONEAL JOINTS

FIBULA

HEAD
Apex of the head
Facet for the tibia
Common peroneal nerve lies very close

BODY
Borders: anterior, posterior, interosseous
Surface: lateral, medial, posterior

DISTAL END (lateral malleolus)
Posterior relative to the medial malleolus
Posterior groove
Medial surface
- triangular articular facet, vertically convex, distal apex
- malleolar fossa, distal, for insertion of posterior talofibular ligament

PROXIMAL TIBIOFIBULAR JOINT

Synovial
Plane (arthrodia). Very little movement

Articular surfaces,
Fibular: round, covered by hyaline cartilage.
Tibial: posterolateral surface of lateral condyle. Faces down, lateral, back

Fibrous capsule, thicker anteriorly, weak

Ligaments (ligamentum capitis fibuli)
- Anterior ligament of the head of the fibula: three fascicles to the lateral condyle
- Posterior ligaments of the head of the fibula, single. Covered by the popliteal tendon.

Vascular supply
branches from the anterior and posterior recurrent branches of the anterior tibial artery

Innervation
Common fibular nerve, nerve to the popliteus

CRURAL INTEROSSEOUS MEMBRANE (*syndesmosis tibiofibularis)*

Inserts on the interosseous borders of fibula and tibia
Plane: proximal is sagittal, distal is frontal
Direction of fascicles: oblique: distal and lateral (prevents the fibula “going down”)
Proximal aperture: anterior tibial vessels
Distal aperture: perforating branch of peroneal artery
Area of insertion of muscles of the leg.

DISTAL TIBIOFIBULAR JOINT

Fibrous joint (syndesmosis)
Articular surfaces:
- tibial concave rough (fibular notch of the tibia: *incisura fibularis*)
- fibular convex

Ligaments
- *Interosseous ligament* — extremely resistant, continuous with the interosseous membrane
- *Anterior tibiofibular ligament* — fibres oriented lateral and distal
- Posterior tibiofibular ligament — similar orientation, thicker

Vascular supply
- perforating branch of the fibular artery
- lateral malleolar branches of the anterior and posterior tibial arteries

Innervation
- Branches form the deep fibular
- Branches of sural nerves

Movements
Very limited. Depend on the movement of the talus
The ligaments determine the width of the tibiofibular mortise

Ankle extension (dorsal flexion)
- The wider anterior part of the trochlear surface of the talus fits in the tibiofibular mortise. This produces that
- The anterior border of the fibula further separates from the tibia (external rotation of the fibula)
- The ligaments tighten, giving more stability
- The posterior tibiofibular ligament, which is stronger acts as hinge in this external rotation of the fibula

18. THE ANKLE JOINT

Functions
1. Support the weight of the body
2. Distribute the weight
3. Movement: walk, adapt the foot to the ground

This is provided by multiple joints (for load sharing), with scarce movement, that summed altogether provide a wider range of movement

BONES

DISTAL TIBIA

Anterior surface

Posterior surface

Lateral surface
Incisura fibularis

Medial surface
Medial malleolus

Distal surface (tibial plafond)
Wider anteriorly
Concave saggitally, convex transversely
Continues medially in the malleolar articular surface

TALUS

Head
Directed distally, inferomedial
Distal articular surface, convex, ovoid
Plantar surface, articular surfaces
- Surface for calcaneonavicular ligament
- Surface for calcaneonavicular part of bifurcate ligament
- Surface for the anterior calcaneal surface — anterior TC joint

Neck
Plantar articular surface for calcaneus (*sustentaculum tali)*, largest, oval, convex. — middle TC joint
Sulcus tali, roof of the tarsal sinus
Axis directed down, distal, medial. 150º with the axis of the body

Body

Dorsal	trochlear surface, convex in sagittal, concave in coronal, widest anteriorly, sagittal axis directed anterior and lateral	
Lateral	triangular facet	
Medial	comma shaped articular facet	
Posterior	posterior process, oblique groove (for FHL) marks two tubercles. Medial tubercle is larger	
Plantar	articular surface for posterior articular surface of calcaneus	posterior TC joint

CALCANEUS
Superior surface has three areas
- Posterior: rough and concavo-convex
- Middle: the posterior talar facet: oval, convex antero-posteriorly
- Anterior:
  - Calcaneus sulcus
  - Articular area: anterior and middle talar facet

Anterior surface: articular facet for the cuboid

Posterior surface: has three areas
- Superior: smooth, covered with fat
- Middle: Ridge for insertion of the calcaneal tendon
- Distal: Subcutaneous weight-bearing surface

Plantar surface

Lateral surface
- Fibular trochlea
- Elevation for insertion of the calcaneofibular ligament

Medial surface
- Sustentaculum tali
- Groove for flexor halluces longus

ANKLE JOINT (talocrural, supratalar)

Synovial
Tibia + fibula + talus
Hinge (trochlea)

ARTICULAR SURFACES

Fibula + tibia = bracket-shaped socket (mortise)
Hyaline cartilage

- Roof: inferior surface of the distal end of the tibia
- Medial side: medial malleolus of the tibia
- Lateral side: lateral malleolus of the fibula, longer

Body of the talus
- Shape of articular surface the talus: half cylinder
- Wider anteriorly than posteriorly: most stable when foot is dorsiflexed

FIBROUS CAPSULE

weak in front and behind (as in all hinge joints). Reinforced by ligaments medially and laterally

SYNOVIAL MEMBRANE:

attaches around the margins of the articular surface.

LIGAMENTS

Medial (deltoid) ligament
Triangular (capital delta)
Apex to the medial malleolus
Base to the navicular and talus
Has 4 parts (named parts, not ligaments)

- Tibionavicular part: attaches in front to the tuberosity of the navicular & margin of the spring ligament
- Tibiocalcaneal part: attaches to the *sustentaculum tali*
- Tibiotalar part, anterior: attaches to the medial surface of the neck of talus
- Tibiotalar part, posterior: attaches to the medial side and medial tubercle of talus

The tibiotalar parts are on a deeper plane than the rest

Lateral ligaments
- Anterior talofibular: from anterior margin of the lateral malleolus → adjacent region of the neck of the talus
- Posterior talofibular: from *malleolar fossa* (medial side of the lateral malleolus) → posterior process of the talus
- Calcaneofibular: from malleolar fossa (posteromedial side of lateral malleolus) → tubercle on lateral surface of calcaneus

INNERVATION

Branches from
- Deep peroneal nerve
- Tibial nerve

MOVEMENTS

Extension (dorsal flexion)
Flexion (plantar flexion)
Trochlea: transverse axis

SUBTALAR JOINT

Talus (posterior calcaneal facet on the inferior surface) + calcaneus (posterior talar facet on the superior surface)
Synovial membrane: two separate joints

POSTERIOR TALOCALCANEAL JOINT

Articular surfaces
- Talus: inferior (posterior) facet of the body, concave, long axis is transverse
- Calcaneus: posterior articular facet, convex

Trochoid
Ligaments
- Talocalcaneal ligaments: Lateral, Medial, Posterior
- Interosseous (tarsal sinus, *sinus tarsi*). Two layers

Vascular supply: branches from plantar, tarsal artery, peroneal artery
Innervation: branches of the posterior tibial, anterior tibial, plantar nerves.

ANTERIOR TALOCALCANEAL JOINT

Articular surfaces
- Talus: two articular facets
- Calcaneus: middle and anterior articular facet, concave

19. JOINTS AND LIGAMENTS OF THE FOOT

NAVICULAR

Proximal surface concave, for head of the talus
Distal surface convex, for cuneiform bones
Medial tuberosity
Plantar surface, groove for the tendon of *tibialis posterior*

CUBOID

Proximal surface for calcaneus
Distal surface: medial quadrangular area for 4th metatarsal, triangular lateral area for 5th metatarsal
Plantar surface
- groove for tendon of *fibularis longus*
- Tuberosity for tendon of *fibularis brevis*

CUNEIFORM BONES

METATARSALS

Base
Triangular (dorsal base, plantar apex)
Proximal articular surface (plane) for
- Cuboid (4th, 5th)
- Cuneiform (1st, 2nd, 3rd)

Body
Tapers distally
Longitudinal border longitudinally concave
Dorsal surface convex in transverse and longitudinal plane

Head:
Condyle.
Lateral tubercles for insertion of collateral ligaments

1st metatarsal: shortest, strongest. Tuberosity.
2nd metatarsal: more rigid, the axis of the foot
3rd metatarsal: shorter
4th metatarsal: shortest
5th metatarsal: longest. Tuberosity in the base (tendon of *peroneus brevis*)

PHALANGES

Base: Base of the proximal phalanx: concavity
Body. Plantar surface plane, dorsal surface convex, oval section
Head: trochlea

INTERTARSAL JOINTS

SUBTALAR JOINT

The *midtarsal joint* (*articulation tarsi transversa)* is formed by
- Talocalcaneonavicular joint
- Calcaneocuboid joint

TALOCALCANEONAVICULAR JOINT

COMPOSITION:
Six bony articular surfaces (3 talus, 2 calcaneus, 1 navicular), one ligamentous
- Talus (anterior and middle calcaneal facets) + Calcaneus (anterior & middle talar facets)
- Talus (medial facet on inferior surface of head) + Calcaneonavicular ligament (spring ligament)
- Talus (ovoid anterior end of head) + Navicular (concave posterior surface)

MOVEMENTS:
- gliding + rotation –> inversion-eversion,
- Pronation-supination

LIGAMENTS
- Posterior: interosseus talocalcaneal ligament
- Superior: Talonavicular ligament
- Inferior: Plantar calcaneonavicular ligament (spring ligament)
- Lateral: calcaneonavicular part of the bifurcate ligament.

Bifurcate ligament, from calcaneus to
- dorsomedial surface of the cuboid (calcaneocuboid ligament)
- Dorsolateral part of the navicular (calcaneonavicular ligament)

Plantar calcaneonavicular ligament (spring ligament): *sustentaculum tali* → navicular bone (supports head of talus)

CALCANEOCUBOID JOINT

Synovial
Sellar
Articular surfaces
- Calcaneus (facet on the anterior surface), concave vertically, convex transversely
- Cuboid (facet of the posterior surface)

MOVEMENTS: sliding, rotating → inversion-eversion, pronation-supination
LIGAMENTS
- Bifurcate ligament
  - Calcaneonavicular
  - Calcaneocuboid
- Plantar calcaneocuboid ligament (short plantar ligament)
- Long plantar ligament: interior surface of calcaneus → inferior surface of the cuboid)

CUNEOCUBOID JOINT

Cuboid + 3rd cuneiform
Arthrodia
Ligaments (cuneocuboid)
- dorsal
- plantar
- interosseous

CUNEONAVICUAR JOINT

Navicular + three cuneiforms
Arthrodias
Single articular capsule
Ligaments: cuneonavicular dorsal + plantar

CUBOIDEONAVICULAR JOINT

Arthrodia

INTERCUNEIFORM JOINTS

2nd cuneiform + 1st & 3rd
Arthrodia
Ligaments: dorsal, plantar, interosseous

JOINTS OF THE FOOT

TARSOMETATARSAL JOINTS

Arthrodias
Movement: limited sliding
Pronation-supination
Plane shape
Overall tarsometatarsal plane: irregular, oblique facing laterally

1st metatarsal – medial cuneiform bone
2nd metatarsal – all three cuneiform bones (socket)
3rd metatarsal – lateral cuneiform bone
4th metatarsal – cuboid
5th metatarsal – cuboid

Three synovial compartments

- Internal	1st cuneiform	1st metatarsal	
- Middle	2nd, 3rd cuneiform	2nd, 3rd metatarsal	communicates with cuneonavicular
- External	Cuboid	4th, 5th metatarsal	

Ligaments

- Dorsal tarsometatarsal ligaments
- Plantar tarsometatarsal ligaments
- Interosseous (internal, middle, lateral)

Innervation

- Medial plantar nerve
- Lateral plantar nerve
- Deep fibular nerve

INTERMETATARSAL JOINTS

Interosseous metatarsal ligament
Dorsal metatarsal ligaments
Plantar metatarsal ligaments

METATARSOPHALANGEAL JOINTS

Head of metatarsals + bases of the proximal phalanges
Head of the first metatarsal has a plantar ridge (between the to sesamoid bones)
Condylar
Synovial

Ligaments:

- Lateral collateral ligaments
- Plantar ligaments: wide, thicker in the phalangeal insertion
- Deep transverse metatarsal ligament, joins all the plantar ligaments

Movements:

Flexion: 30-40º. With some adduction
Extension: 50-60º active, 90º. With some abduction (5th toe also adduction)
The second is stiffer

INTERPHALANGEAL JOINTS

Trochlea
Collateral ligaments (medial, lateral)
Plantar ligament

Movements:

Flexion-extension
Locked position is flexion (collateral ligaments tighten)
Accessory ad/abduction, passive rotation

ARCHES OF THE FOOT

Transverse arch
- Anterior
- Posterior

Longitudinal arch
- Medial
- Lateral