THEORY · WEEK 1

Introduction: Anatomical Position, Planes, Directional Terms & Body Systems

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

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Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

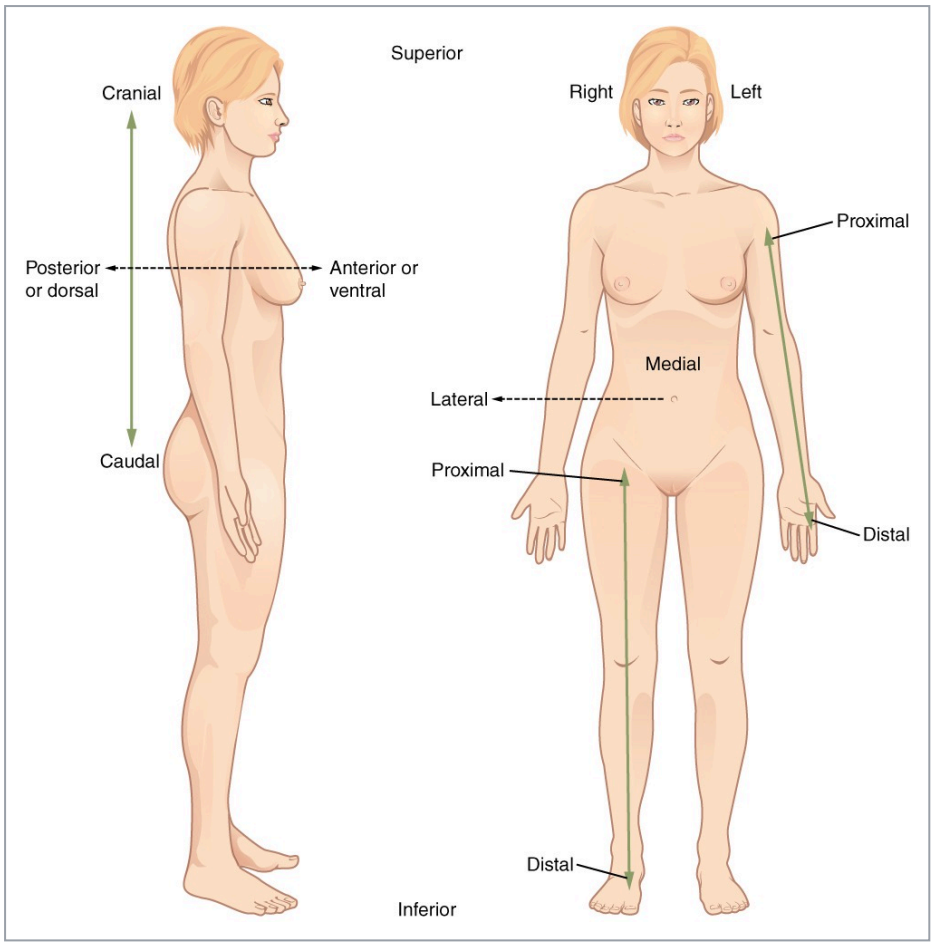
- Define anatomy and explain why it matters in prosthetics and orthotics (P&O).
- Describe the anatomical position and the three anatomical planes.
- Use directional terms accurately to locate body structures.
- List the major body systems and their relevance to P&O practice.

1. What is Anatomy?

Anatomy is the scientific study of the structure of the human body and the relationships between its parts. For students of Prosthetics & Orthotics Technology, sound anatomical knowledge is the foundation for identifying amputation levels, understanding joint movement, locating pressure-tolerant and pressure-sensitive areas, designing sockets and orthotic devices, and knowing where nerves, vessels and muscles lie in relation to bones.

2. The Anatomical Position

The **anatomical position** is the standard reference posture: the body stands upright, head and eyes face forward, arms at the sides with **palms facing forward**, and feet parallel and directed forward. All directional terms assume this position.

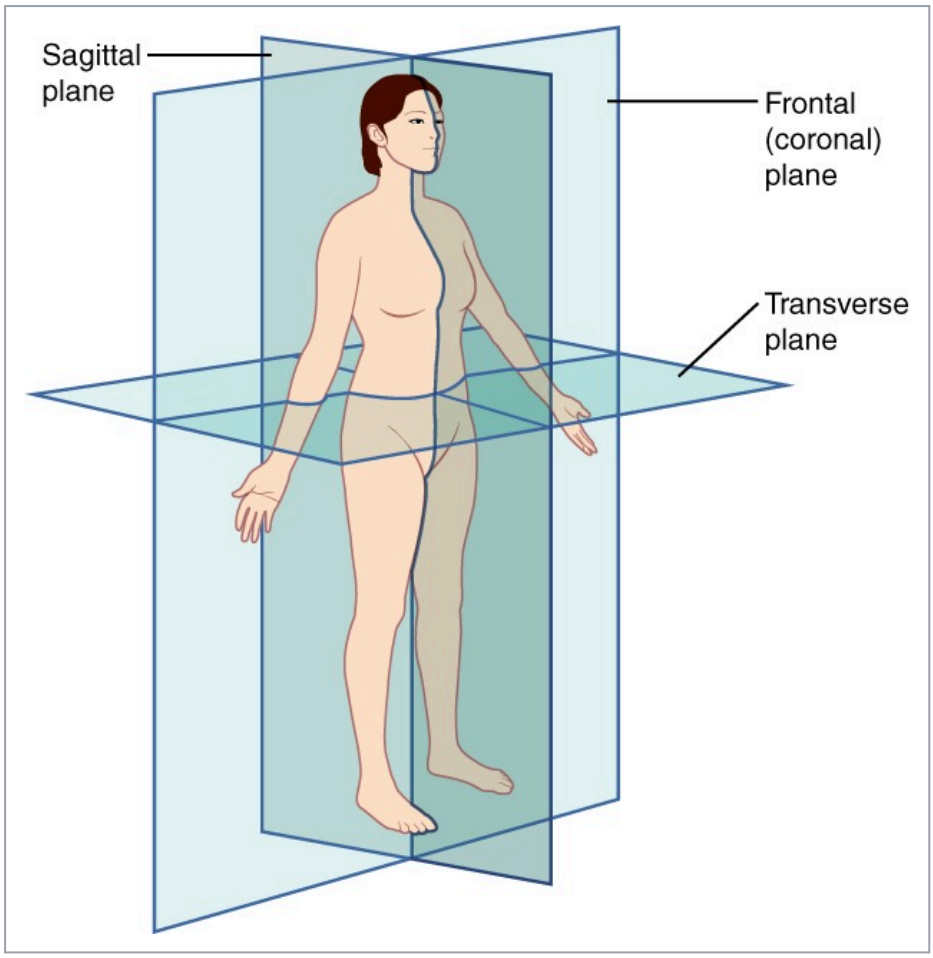


The body in the anatomical position, showing the principal directional terms (superior/inferior, anterior/posterior, medial/lateral, proximal/distal, cranial/caudal).

> **P&O relevance**
>
> The anatomical position provides a universal reference for describing structures, defining amputation levels (e.g. distal femur, proximal tibia), and understanding prosthetic alignment and joint axes.

3. Anatomical Planes

The body is divided into sections by three imaginary planes, each associated with characteristic movements.



The three anatomical planes — sagittal, frontal (coronal) and transverse.

Plane	Divides body into	Typical movements	P&O importance
Sagittal	Right & left	Flexion / extension	Gait analysis; prosthetic knee motion
Frontal (coronal)	Anterior & posterior	Abduction / adduction	Balance & lateral stability
Transverse (horizontal)	Superior & inferior	Rotation	Hip rotation & prosthetic alignment

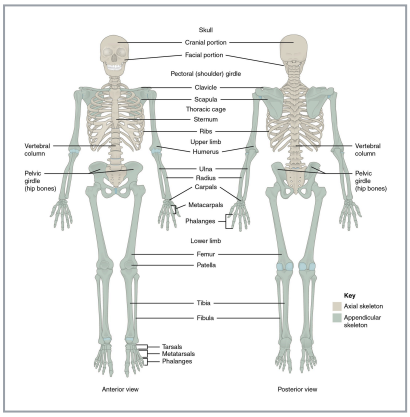
4. Directional Terms

Term	Meaning	Term	Meaning
Superior	Above	Inferior	Below
Anterior	Front	Posterior	Back
Medial	Toward the midline	Lateral	Away from the midline
Proximal	Closer to the trunk	Distal	Farther from the trunk
Superficial	Near the surface	Deep	Away from the surface
Ipsilateral	Same side	Contralateral	Opposite side

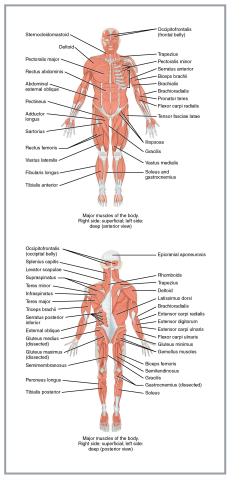
P&O examples

The patella is *anterior* to the femur · the *distal* tibia is a common trans-tibial amputation level · the *lateral* malleolus must be relieved inside a trans-tibial socket · the *medial* femoral condyle is a pressure-sensitive area in above-knee (AK) sockets.

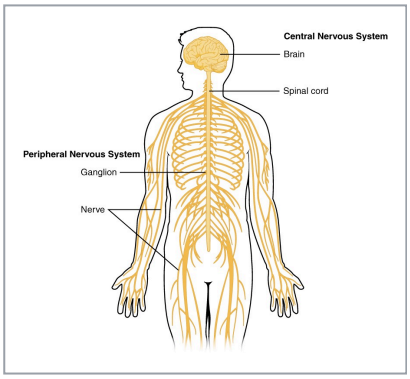
5. Overview of Body Systems



Skeletal system.



Muscular system.



Nervous system.

System	Core role	Relevance to P&O
Skeletal	206 bones — structure, protection, movement	Alignment, limb segments, weight-bearing surfaces, joint biomechanics
Muscular	Skeletal, smooth & cardiac muscle — movement	Residual-limb muscle function; forces on prosthetic joints
Nervous	CNS & PNS — sensation & control	Phantom-limb sensation; nerve injury; motor control
Circulatory	Transports blood, O_2, nutrients	Wound healing; poor circulation → socket ulcers
Integumentary (skin)	Skin, hair, nails — barrier & sensation	Skin breakdown; pressure management; friction injuries

Key terms

Anatomical position · **sagittal / frontal / transverse planes** · **superior–inferior** · **medial–lateral** · **proximal–distal** · **superficial–deep**.

Assignment

Write a short paragraph (6–8 sentences) describing any part of the body using at least **3 directional terms**, **1 anatomical plane**, and **1 example** relating the structure to prosthetic or orthotic practice.

THEORY · WEEK 2

The Skeletal System: Bone Types, Structure & Growth

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

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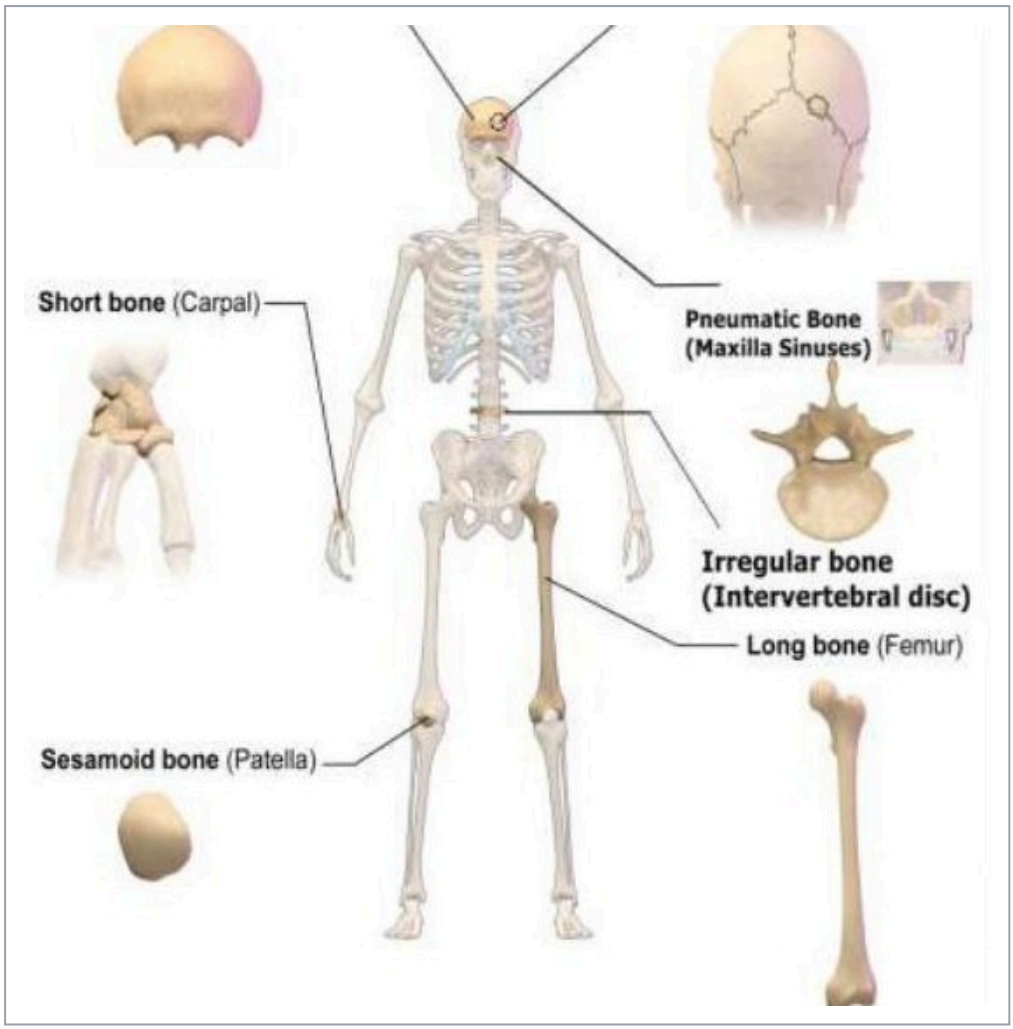
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- Classify bones by shape and give examples of each class.
- Describe the gross and microscopic structure of a long bone.
- Explain the roles of osteoblasts, osteoclasts and osteocytes.
- Describe longitudinal and appositional growth and the factors that influence them.
- Relate bone behaviour to amputation, socket design and remodelling.

The skeletal system is the structural framework of the body. It provides support and protection, enables movement, stores minerals (calcium & phosphate), forms blood cells (hematopoiesis), and transmits forces during locomotion. Because bone is a living, dynamic tissue, it continually remodels in response to mechanical load.

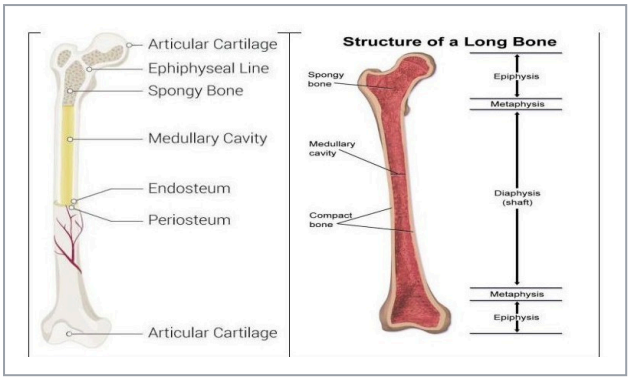
1. Classification of Bones (by Shape)



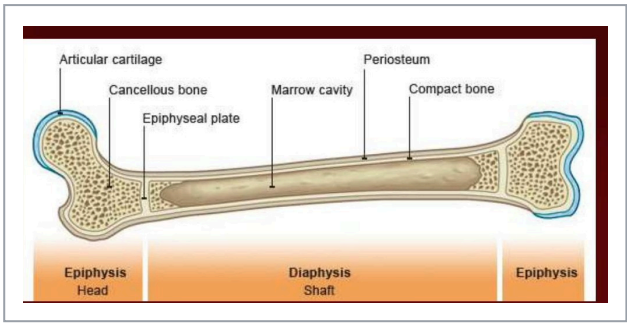
The classes of bone by shape, with representative examples.

Type	Characteristics	Examples	P&O note
Long	Longer than wide; shaft + two ends; medullary cavity	Femur, tibia, fibula, humerus, radius, ulna	Most lower-limb amputations involve long bones
Short	Cube-shaped; strength with little motion	Carpals, tarsals	Foot biomechanics & orthotic design
Flat	Thin, flattened, often curved	Skull, scapula, sternum, ribs	Broad surface for muscle attachment
Irregular	Complex shapes	Vertebrae, mandible, sacrum	Spinal posture & pelvic alignment
Sesamoid	Develop within tendons	Patella	Knee-extension mechanism & prosthetic knee alignment

2. Gross (Macroscopic) Structure of a Long Bone



External & internal structure of a long bone.



Diaphysis, epiphysis & medullary cavity.

- **Diaphysis** — the shaft; compact bone surrounding the medullary cavity.
- **Epiphyses** — the ends; mostly spongy bone, covered by articular cartilage.
- **Metaphysis** — between diaphysis and epiphysis; contains the growth plate in children.
- **Articular cartilage** — hyaline cartilage that reduces friction and absorbs shock.
- **Periosteum** — outer fibrous membrane, rich in vessels and nerves; vital for healing and anchorage.
- **Medullary cavity** — yellow (fatty) marrow in adults; red marrow in children.

> **P&O relevance**
>
> **Periosteal pain** is common after amputation because of the nerve-rich periosteum, so bony ends must be well padded inside the socket.

3. Microscopic Structure (Histology)

Compact bone	Spongy (cancellous) bone
Dense & strong; organised into **osteons** (Haversian systems): Haversian canals, lamellae, lacunae (osteocytes), canaliculi.	Lattice of **trabeculae**; lighter, more flexible; contains red marrow.

> **P&O relevance**
>
> Trabecular bone adapts quickly to changes in loading — central to **residual-limb remodelling**.

4. Bone Cells

- **Osteoblasts** — bone-forming; produce new matrix (osteoid); active in healing and growth.
- **Osteoclasts** — bone-resorbing; dissolve matrix; essential for remodelling and calcium balance.
- **Osteocytes** — mature cells in lacunae; sense mechanical stress and regulate remodelling.

5. Bone Growth

Longitudinal growth (lengthening) occurs at the epiphyseal plate through ordered zones: resting → proliferation → hypertrophic → calcification → ossification. **Appositional growth** (thickening) occurs as

osteoblasts add bone to the outer surface while osteoclasts remove bone from the inner surface.

> **Wolff's Law.** Bone grows and remodels according to the mechanical stress placed upon it.

6. Factors Influencing Bone Growth

Nutrition (calcium, phosphorus, vitamin D) · **hormones** (growth hormone, thyroid hormone, estrogen & testosterone) · **mechanical load** (Wolff's Law).

> **Skeletal adaptation in amputation & prosthetics**
>
> After amputation, loss of normal loading causes **bone atrophy** at the distal end, shape change of the residual limb, periosteal sensitivity, and possible bony prominences. Socket design directs load toward **pressure-tolerant areas** (patellar tendon, medial tibial flare, lateral femoral shaft) and away from **pressure-sensitive areas** (tibial crest, fibular head, distal femur).

Assignment

Write a detailed paragraph (10–12 sentences) about the femur: its classification, structural parts, mechanical function, importance in trans-femoral (AK) prosthetic alignment, and clinical issues after trans-femoral amputation.

THEORY · WEEK 3

Axial Skeleton: Skull Overview & Vertebral Column

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

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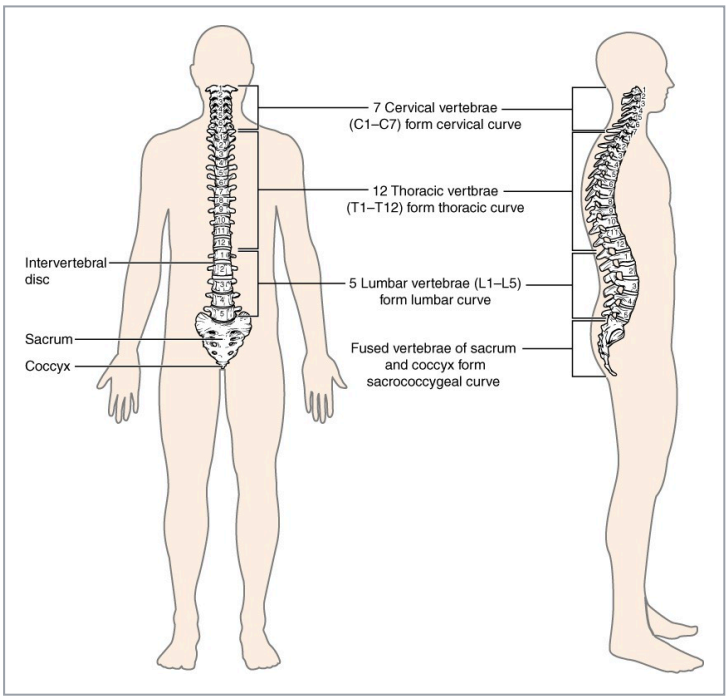
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- State the components and functions of the axial skeleton.
- List the cranial and facial bones and the functions of the skull.
- Describe the regions of the vertebral column and the structure of a typical vertebra.

1. The Axial Skeleton

The human skeleton is divided into the **axial skeleton** (skull, vertebral column, ribs and sternum) and the **appendicular skeleton** (limbs and girdles). The axial skeleton forms the central axis of the body (~80 bones) and supports the head, neck and trunk; protects the brain, spinal cord, heart and lungs; and provides muscle attachment.



The vertebral column — central axis of the axial skeleton.

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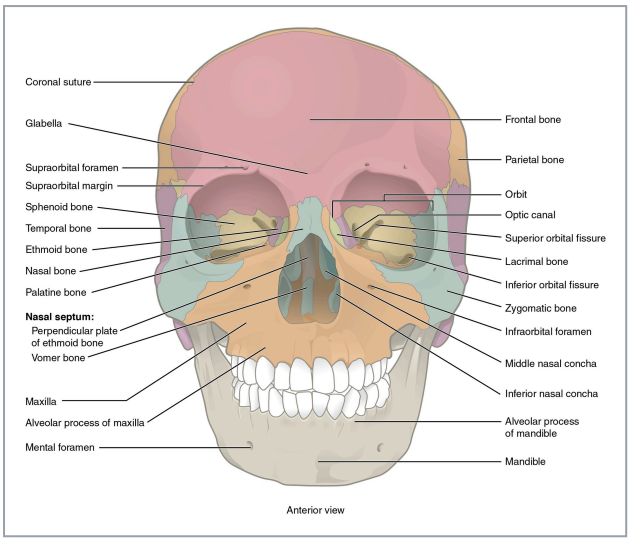
2. The Skull

The skull contains **22 bones**: 8 cranial and 14 facial, plus the middle-ear ossicles and the hyoid.



Skull — anterior view.

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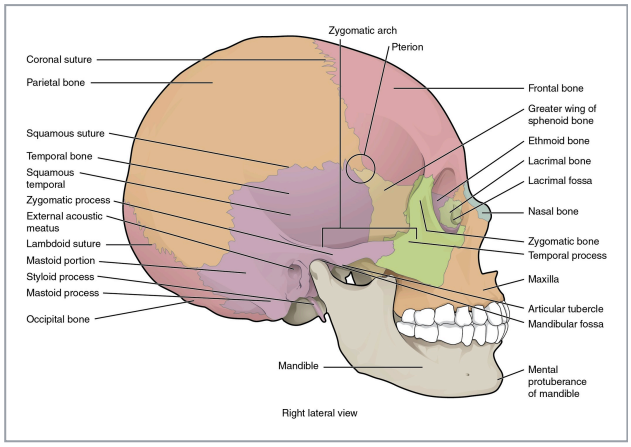

Skull — lateral view.

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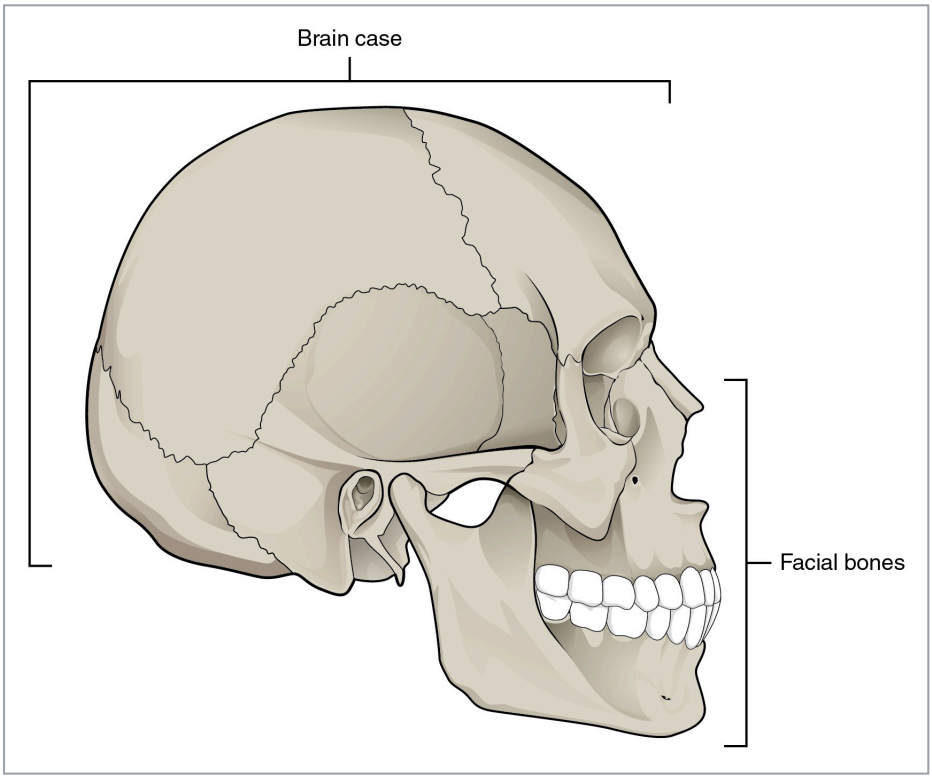

The skull divides into the brain case (8 cranial bones) and the facial skeleton (14 facial bones).

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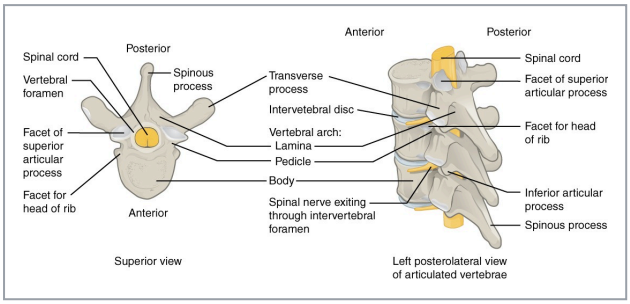
Cranial bones (8)

Frontal · two Parietal · two Temporal · Occipital (contains the *foramen magnum*) · Sphenoid · Ethmoid.

Facial bones (14)

Maxillae (2) · Zygomatic (2) · Nasal (2) · Palatine (2) · Lacrimal (2) · Inferior nasal conchae (2) · Vomer (1) · **Mandible** (1 — the only movable skull bone).

3. The Vertebral Column



A typical vertebra.

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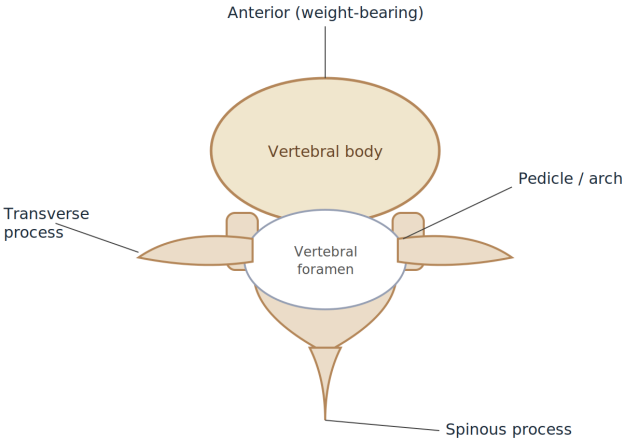

Superior view of a typical vertebra

Vertebra — superior view (diagram).

Region	Vertebrae	Location / function
Cervical	7 (C1–C7)	Neck — supports the skull, allows head movement
Thoracic	12 (T1–T12)	Upper/mid back — each articulates with a pair of ribs
Lumbar	5 (L1–L5)	Lower back — bears much body weight
Sacral	5 → Sacrum	Forms posterior pelvis
Coccygeal	3–5 → Coccyx	Vestigial; ligament/muscle attachment

P&O relevance

Spinal posture and pelvic alignment directly influence the prescription of spinal orthoses and the gait of lower-limb prosthesis users; the skull–C1 (atlas) articulation underlies head control in cervical orthoses.

Key terms

Axial skeleton · **cranial vs facial bones** · **foramen magnum** · **vertebral body** · **vertebral foramen** · **intervertebral disc**.

THEORY · WEEK 4

Vertebral Column: Regional Differences & Intervertebral Discs

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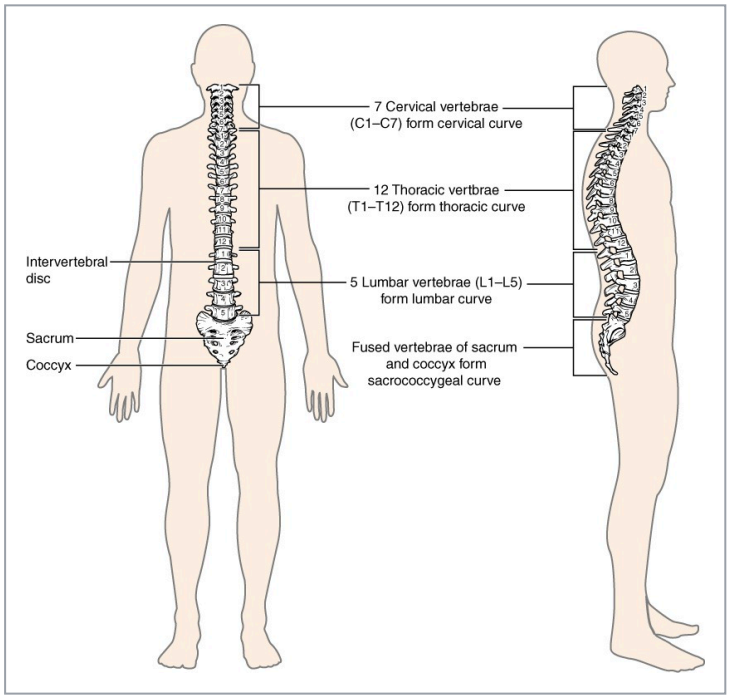
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- Compare cervical, thoracic, lumbar, sacral and coccygeal vertebrae.
- Describe the normal curvatures of the spine and their mechanical value.
- Explain the structure and function of intervertebral discs.

1. Overview



The five regions and curvatures of the vertebral column.

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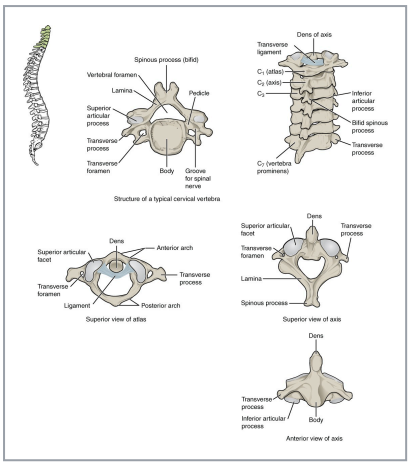
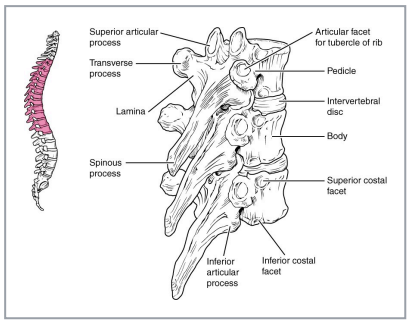
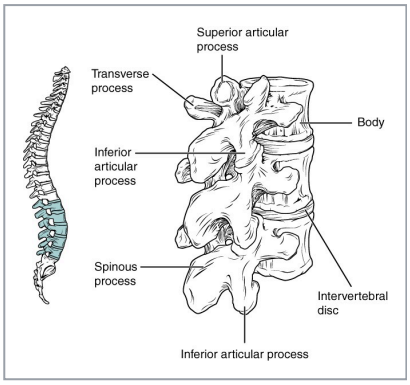
2. Regional Differences



Cervical (C1–C7), incl. atlas & axis.

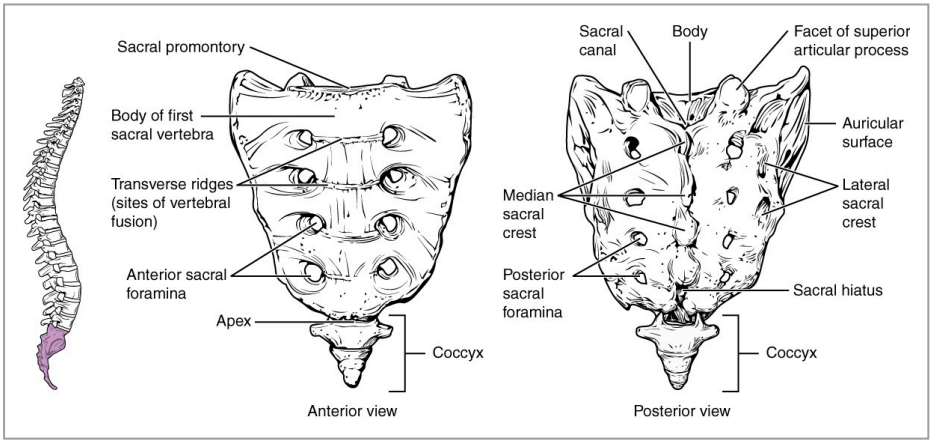


Thoracic vertebra (costal facets).



Lumbar (L1–L5).

Region	Distinguishing features
Cervical	Small bodies; **transverse foramina**; often bifid spinous process; triangular foramen. C1 = Atlas (ring, no body); C2 = Axis (has the dens).
Thoracic	Heart-shaped bodies; **costal facets** for ribs; long downward-sloping spinous processes.
Lumbar	Largest, strongest bodies; short, broad spinous processes; built for weight-bearing.
Sacrum & coccyx	Fused, immovable; sacrum transfers weight to the pelvic girdle.

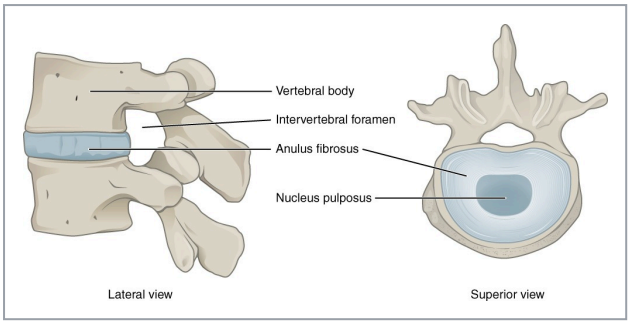


The sacrum & coccyx (anterior & posterior views).

3. Spinal Curvatures

The adult spine has four curvatures acting like a spring to distribute load: **cervical** (secondary), **thoracic** (primary), **lumbar** (secondary) and **sacrococcygeal** (primary).

4. Intervertebral Discs



Disc: annulus fibrosus + nucleus pulposus.
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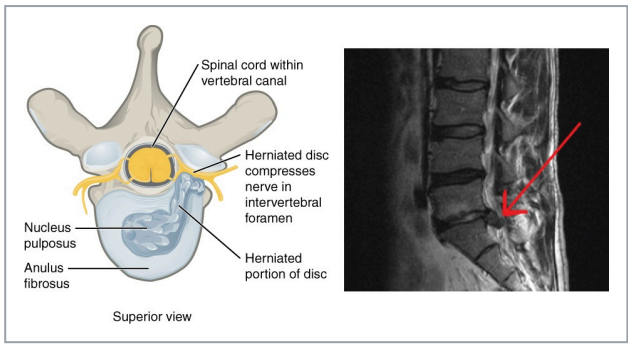

Herniated ("slipped") disc compressing a nerve.
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- **Annulus fibrosus** — tough outer ring of concentric collagen fibres (tensile strength).
- **Nucleus pulposus** — soft, water-rich core acting as a shock absorber.

Functions: shock absorption · flexibility & mobility · maintaining spacing for spinal-nerve exit · contributing to spinal curvatures and posture.

Clinical & P&O relevance

Discs can **degenerate** or **herniate**: a weakened annulus lets the nucleus pulposus bulge and compress nearby nerves, causing pain and neurological symptoms. Spinal orthoses are often prescribed to offload and stabilise affected segments.

Quick self-check

1. Which vertebrae carry transverse foramina, and what passes through them?
2. Name the two parts of an intervertebral disc and the role of each.
3. Which spinal curvatures are *primary* and which are *secondary*?

THEORY · WEEK 5

Thoracic Cage: Ribs, Sternum & Functions

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

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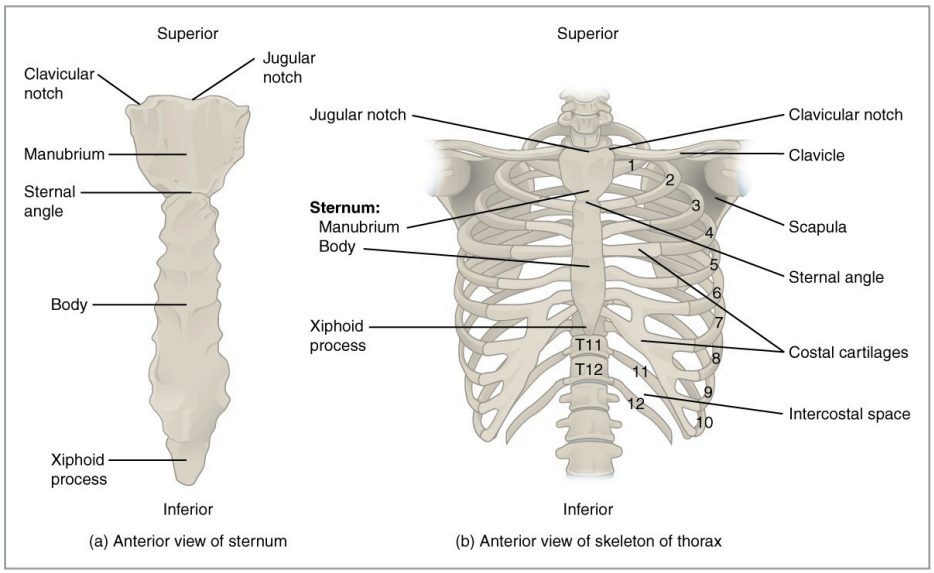
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- Describe the components of the thoracic cage.
- Identify the parts of a typical rib and classify ribs by their attachment.
- Describe the parts of the sternum and the sternal angle.
- Explain the functions of the thoracic cage, including respiration.

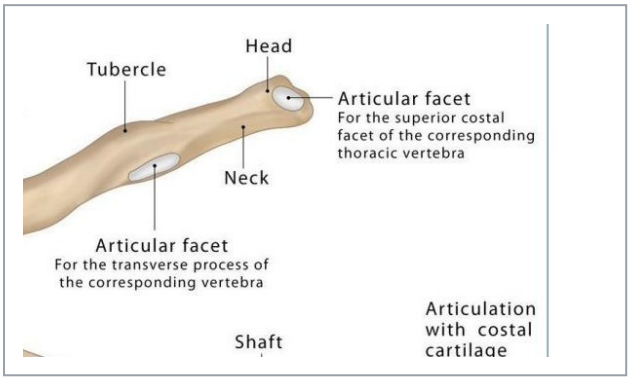
1. Overview



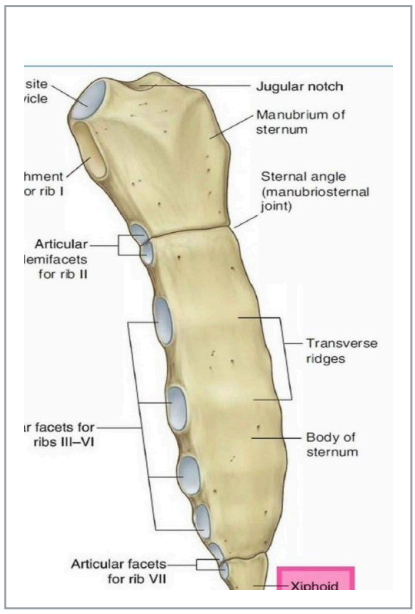
The thoracic cage — ribs, costal cartilages, sternum and thoracic vertebrae.

The **thoracic cage** consists of **12 pairs of ribs** with their costal cartilages, the **sternum** anteriorly, and the **12 thoracic vertebrae** posteriorly.

2. A Typical Rib & Classification



Parts of a typical rib: head, neck, tubercle, shaft.



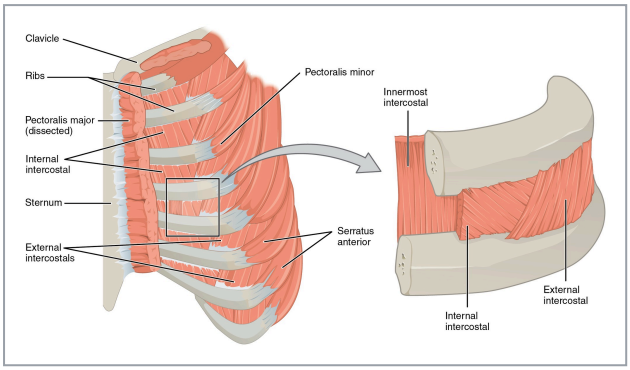
Sternum: manubrium, body, xiphoid; sternal angle.

Group	Ribs	Attachment to sternum
True (vertebrosternal)	1–7	Own costal cartilage attaches directly
False (vertebrochondral)	8–10	Cartilage attaches to the rib above
Floating	11–12	No anterior attachment

3. The Sternum & Respiration

- **Manubrium** — broad superior part; notches for clavicles and 1st costal cartilages.
- **Body** — middle part; articulates with cartilages of ribs 2–7.
- **Xiphoid process** — small inferior tip.

> **Sternal angle (angle of Louis).** Junction of manubrium and body — marks the level of the **2nd rib**; a key clinical landmark.



Muscles of the thorax (intercostals).

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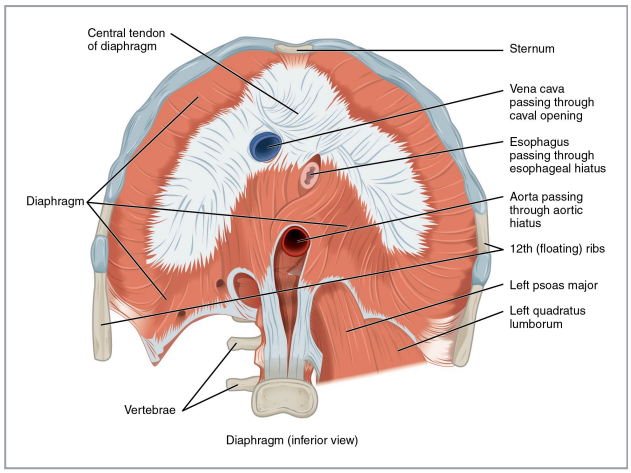

The diaphragm.

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4. Functions of the Thoracic Cage

- **Protection** of the heart, lungs and great vessels.
- **Support & muscle attachment** for chest, back, neck and upper limb.
- **Respiration** — diaphragm and intercostals change thoracic volume.
- **Attachment** for the upper limb via the shoulder girdle.

> **P&O relevance**
>
> Thoracic anatomy underlies spinal orthoses (e.g. TLSO) and upper-limb harnessing, where forces transmit across the rib cage and shoulder girdle. Respiratory excursion must not be over-restricted by an orthosis.

THEORY · WEEK 6

Appendicular Skeleton: Upper Limb Bones

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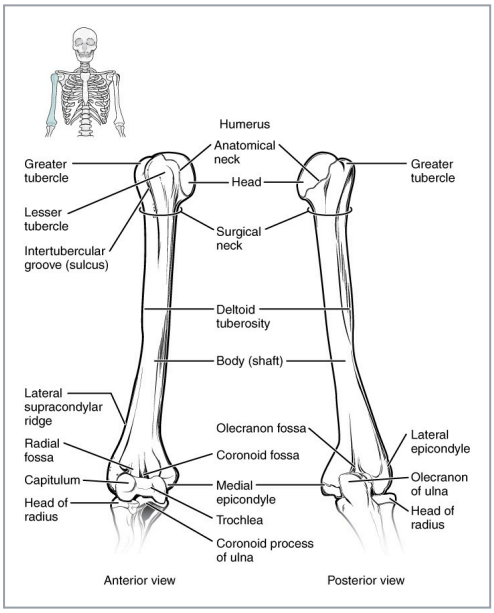
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- Outline the four regions and 32 bones of each upper limb.
- Describe the pectoral girdle, arm, forearm and hand bones and their key features.
- Explain why the upper limb favours mobility over stability.

1. Arm & Forearm

Each upper limb has **32 bones** across four regions: pectoral girdle (clavicle, scapula), arm (humerus), forearm (radius, ulna) and hand. The upper limb is specialised for **mobility, precision and manipulation**.



Humerus & elbow region.

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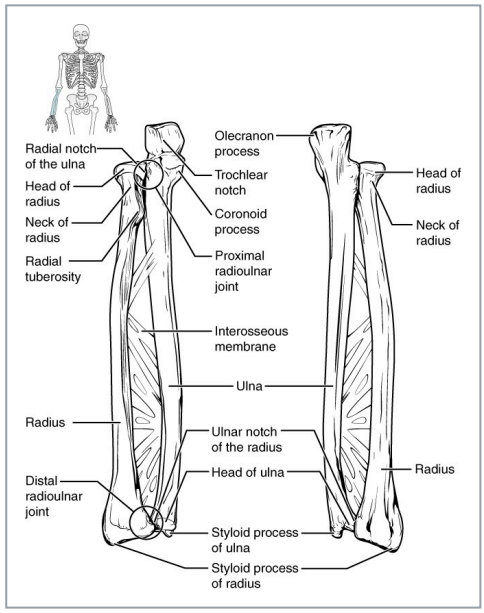

Radius & ulna (forearm).

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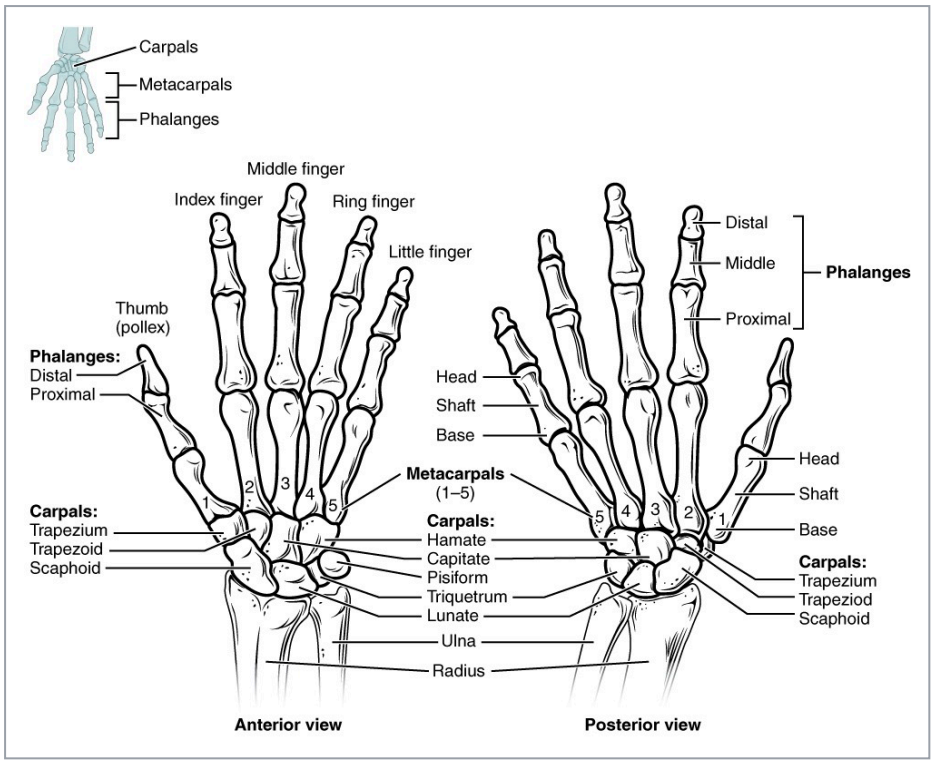
2. The Hand



Carpals (8), metacarpals (5) & phalanges (14).

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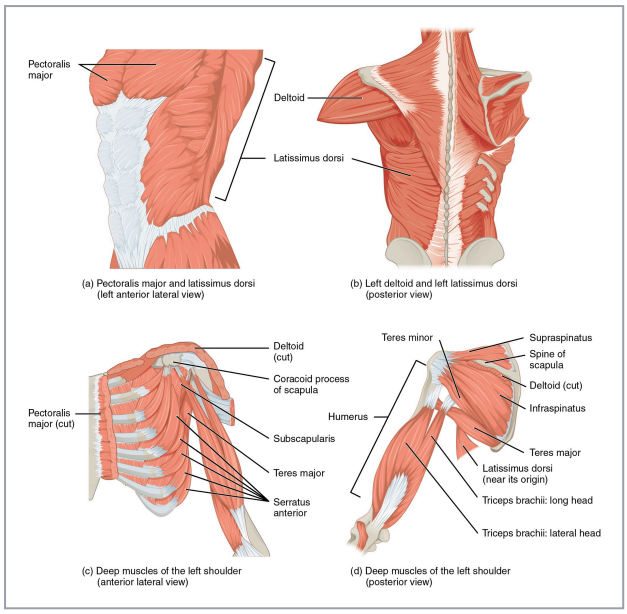
Region	Bones
Pectoral girdle	Clavicle, Scapula
Arm	Humerus
Forearm	Radius (lateral), Ulna (medial)
Wrist (carpals)	8 bones (2 rows)
Palm (metacarpals)	5 bones (I–V)
Fingers (phalanges)	14 bones (thumb 2; others 3 each)

3. Muscles that Move the Upper Limb



Muscles acting on the humerus & shoulder.

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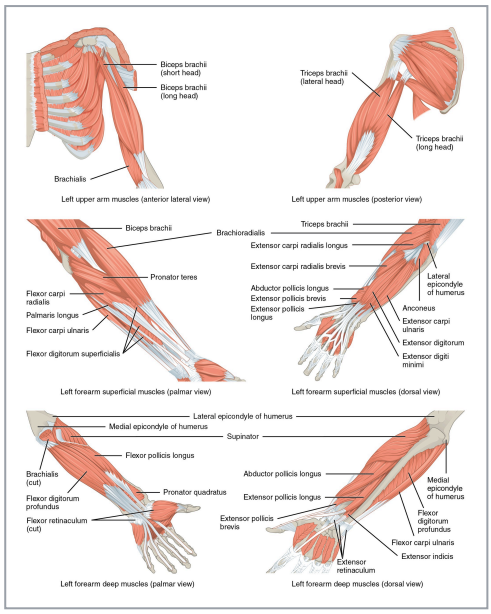

Muscles acting on the forearm.

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P&O relevance

The shallow glenoid cavity and mobile joints make the upper limb mobile but less stable than the lower limb — key when fitting upper-limb prostheses and orthoses, where preserving range of motion at the shoulder and wrist is essential for function and tool use.

THEORY · WEEK 7

Appendicular Skeleton: Lower Limb Bones

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

Assist. Lect. Redha Dawood Abdul-Redha · م.م. رضا داود عبد الرضا

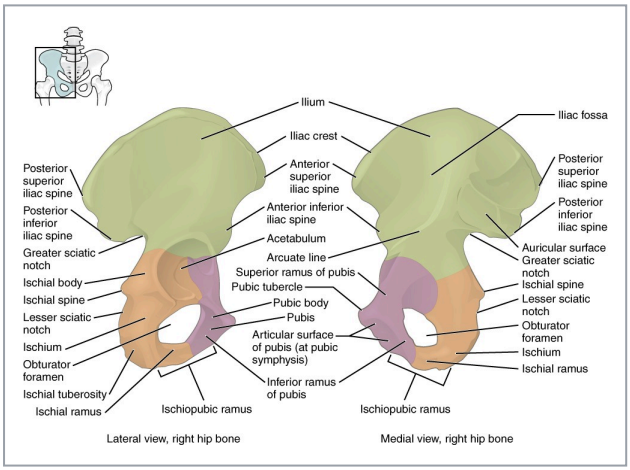
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- Describe the bones and key landmarks of the pelvic girdle, thigh, leg and foot.
- Compare the male and female pelvis.
- Describe the arches of the foot and their weight-bearing role.
- Relate lower-limb landmarks to amputation levels and socket design.

1. Pelvic (Hip) Girdle

Each lower limb has **32 bones**. Because they carry the body's full weight, lower-limb bones are thicker and stronger than their upper-limb counterparts.



Hip bone: ilium, ischium, pubis (acetabulum).

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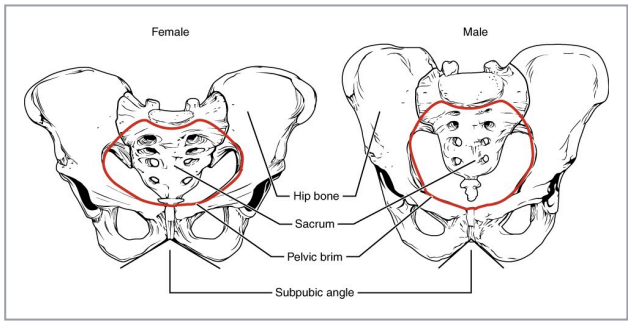

Male vs female pelvic girdle.

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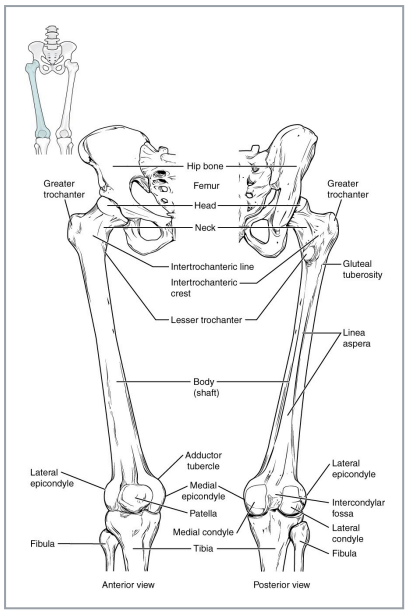
2. Thigh & Leg



Femur & patella (thigh).

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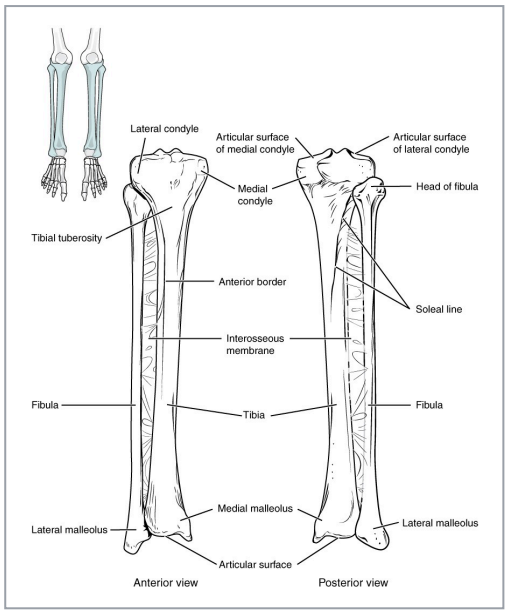

Tibia & fibula (leg).

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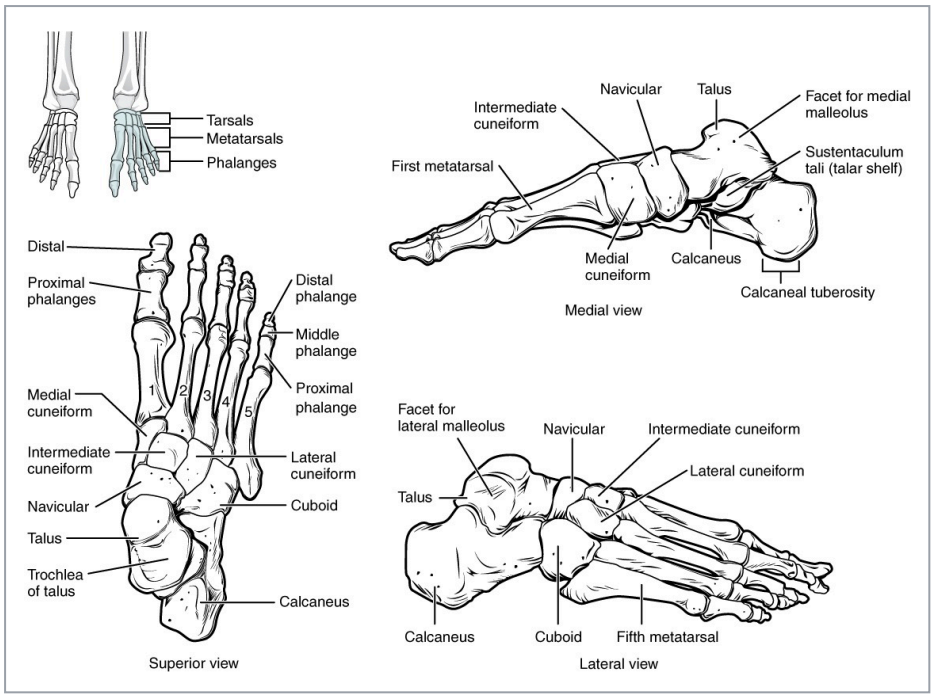
Bone	Key landmarks
Femur	Head, neck, greater & lesser trochanters, linea aspera, medial & lateral condyles
Tibia (medial, weight-bearing)	Condyles, **tibial tuberosity**, anterior crest, **medial malleolus**
Fibula (lateral)	Head (proximal), **lateral malleolus** (distal)

3. The Foot



Tarsals (7), metatarsals (5) & phalanges (14); the foot arches.

P&O relevance — pressure mapping

Pressure-tolerant areas (patellar tendon, medial tibial flare, ischial tuberosity, fibular shaft) bear load, while **pressure-sensitive** areas (tibial crest, fibular head, distal tibia/femur, malleoli) must be relieved. Foot arches guide foot-orthosis and prosthetic-foot design.

Key terms

Acetabulum · **ischial tuberosity** · **femoral condyles** · **tibial tuberosity** · **medial & lateral malleoli** · **tarsus / metatarsus / phalanges** · **foot arches**.

THEORY · WEEK 8

Midterm Examination & Consolidation Review

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

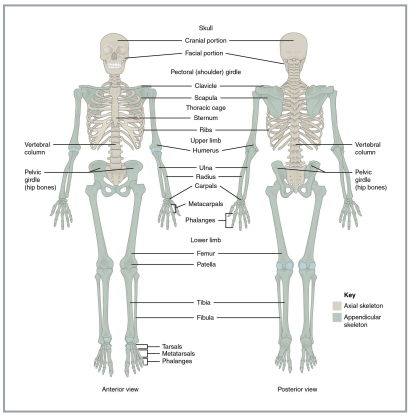
Assist. Lect. Redha Dawood Abdul-Redha · م.م. رضا داود عبد الرضا

Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

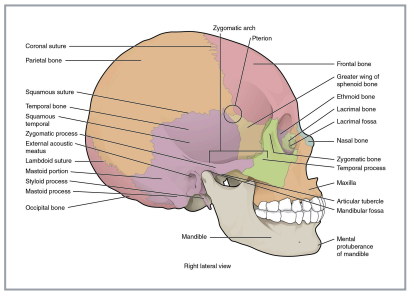
Week 8 is the midterm examination, covering Weeks 1–7. Use the review below to consolidate.

Themes covered (Weeks 1–7)

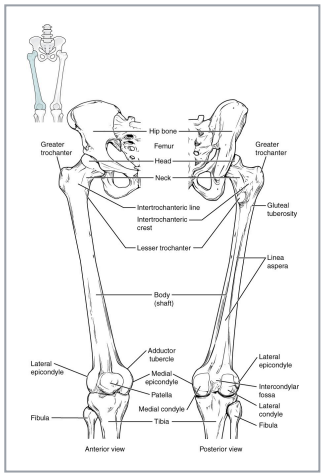
- Anatomical position, planes and directional terms; overview of body systems.
- Bone classification, structure, cells and growth (Wolff's Law).
- Axial skeleton: skull, vertebral column (regions, vertebra structure, discs).
- Thoracic cage: ribs, sternum, articulations and functions.
- Appendicular skeleton: upper- and lower-limb bones and landmarks.



Full skeleton.



Skull (lateral).



Femur & patella.

Sample review questions

1. Define the anatomical position and name the movement associated with each plane.
2. List the five bone classes by shape with one example of each.
3. Label a long bone: diaphysis, epiphysis, metaphysis, periosteum, medullary cavity.
4. Compare cervical, thoracic and lumbar vertebrae.
5. Classify the ribs and locate the sternal angle.
6. Name the three bones that fuse to form the os coxa and the socket they create.
7. For three lower-limb landmarks, state whether each is pressure-tolerant or pressure-sensitive.

Exam preparation tip

Practise on the laboratory models (Labs 1–7): being able to *identify and orient* a bone is as important as naming its parts. Link every structure to a P&O application where you can.

THEORY · WEEK 9

Joints: Classification & Structure of Synovial Joints

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

Assist. Lect. Redha Dawood Abdul-Redha · **م.م. رضا داود عبد الرضا**

Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

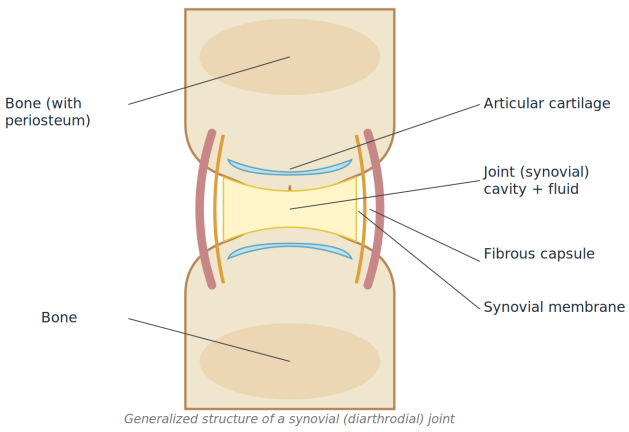
- Classify joints functionally and structurally.
- Describe the features common to all synovial joints.
- Identify the six types of synovial joint with examples.
- Relate joint structure and joint axes to prosthetic and orthotic design.

1. Functional & Structural Classification

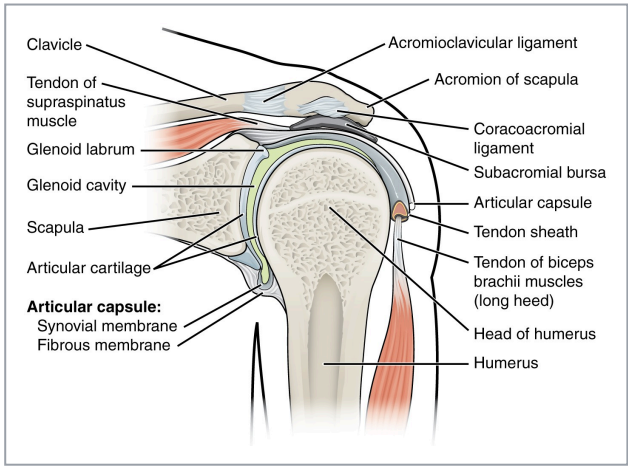
Class	Mobility	Example
Synarthrosis	Immovable	Skull sutures
Amphiarthrosis	Slightly movable	Intervertebral discs, pubic symphysis
Diarthrosis	Freely movable	All synovial joints

Structurally: **fibrous** (sutures), **cartilaginous** (discs), and **synovial** (most limb joints) joints.

2. Structure of a Synovial Joint



Generalised synovial joint.

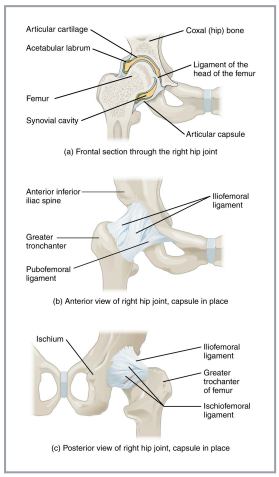


Shoulder joint (real example).

- **Articular cartilage** — covers bone ends; reduces friction, absorbs shock.
- **Joint (synovial) cavity** — contains lubricating synovial fluid.
- **Articular capsule** — fibrous outer layer + inner **synovial membrane**.

- **Reinforcing ligaments** — strengthen and stabilise; some joints add menisci/bursae.

3. Types of Synovial Joints



Hip — ball-and-socket.
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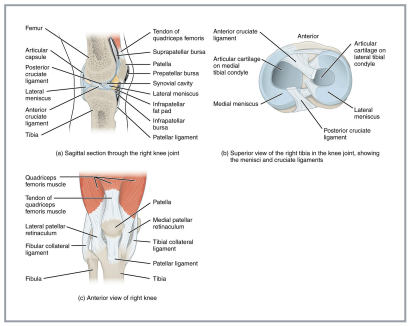

Knee — modified hinge.
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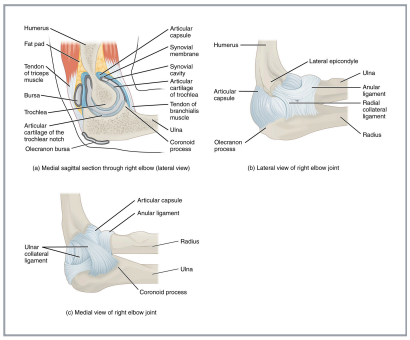

Elbow — hinge.
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Type	Movement	Example
Hinge	Flexion/extension (1 axis)	Elbow, knee
Pivot	Rotation (1 axis)	Atlanto-axial (C1–C2)
Ball-and-socket	Multi-axial	Shoulder, hip
Condyloid	Two axes	Wrist (radiocarpal)
Saddle	Two axes	Thumb carpometacarpal
Plane (gliding)	Short gliding	Intercarpal, intertarsal

P&O relevance — joint axes

Prosthetic and orthotic joints mimic the **axis** and degrees of freedom of the joint they replace. A prosthetic knee reproduces a sagittal-plane hinge; aligning the mechanical axis with the anatomical joint axis is essential for a stable, energy-efficient gait and to avoid abnormal stress and skin breakdown.

Key terms

Synarthrosis / amphiarthrosis / diarthrosis · **articular cartilage** · **synovial membrane & fluid** · **hinge / pivot / ball-and-socket** · **joint axis**.

THEORY · WEEK 10

The Muscular System: Muscle Types, Structure & Contraction

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

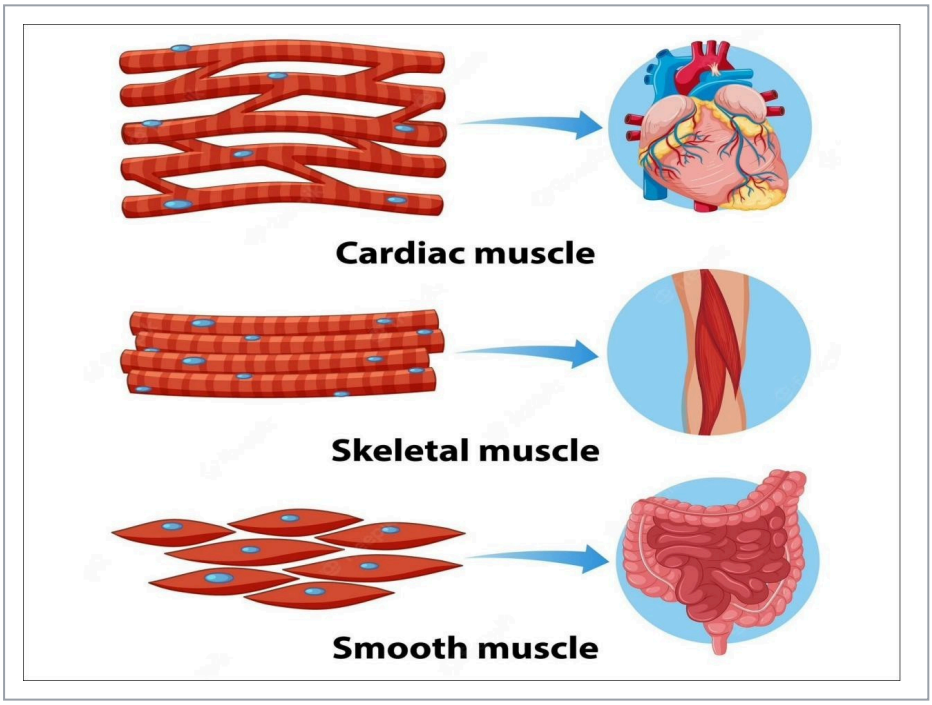
Assist. Lect. Redha Dawood Abdul-Redha · **م.م. رضا داود عبد الرضا**

Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- Distinguish the three types of muscle tissue.
- Describe the structural organisation of skeletal muscle.
- Outline the sliding-filament mechanism of contraction.
- Relate muscle function to residual-limb control and prosthetic forces.

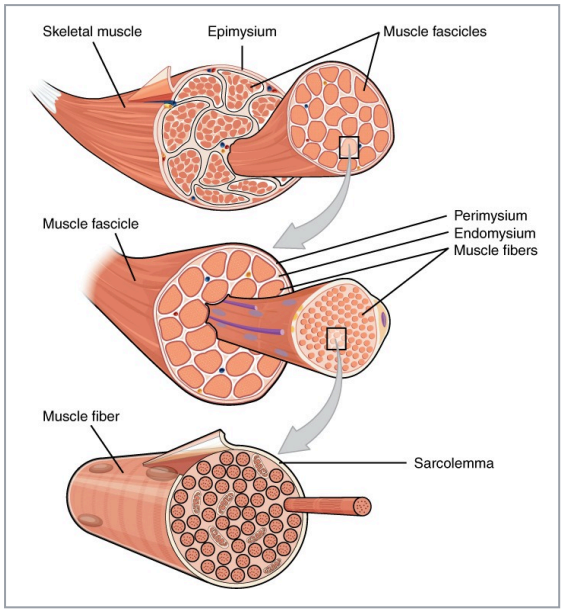
1. Three Types of Muscle Tissue



Cardiac, skeletal and smooth muscle.

Type	Control	Striations	Location
Skeletal	Voluntary	Striated	Attached to bones
Cardiac	Involuntary	Striated	Heart wall
Smooth	Involuntary	Non-striated	Walls of hollow organs & vessels

2. Structural Organisation of Skeletal Muscle



Muscle → fascicle → fibre → myofibril.

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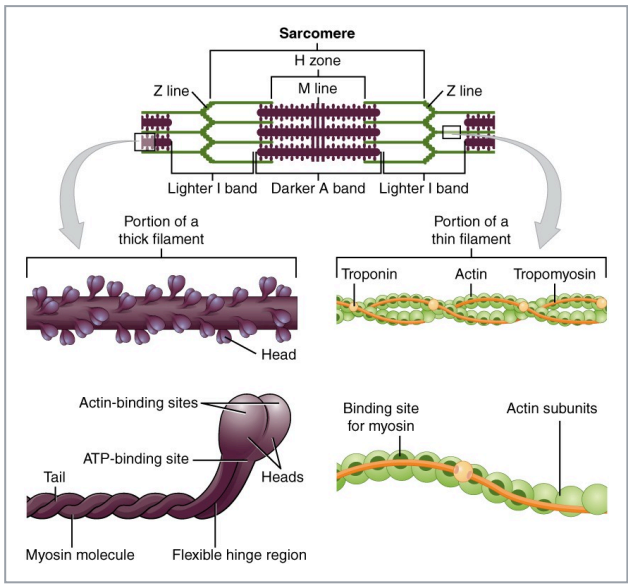

Sarcomere: actin & myosin filaments.

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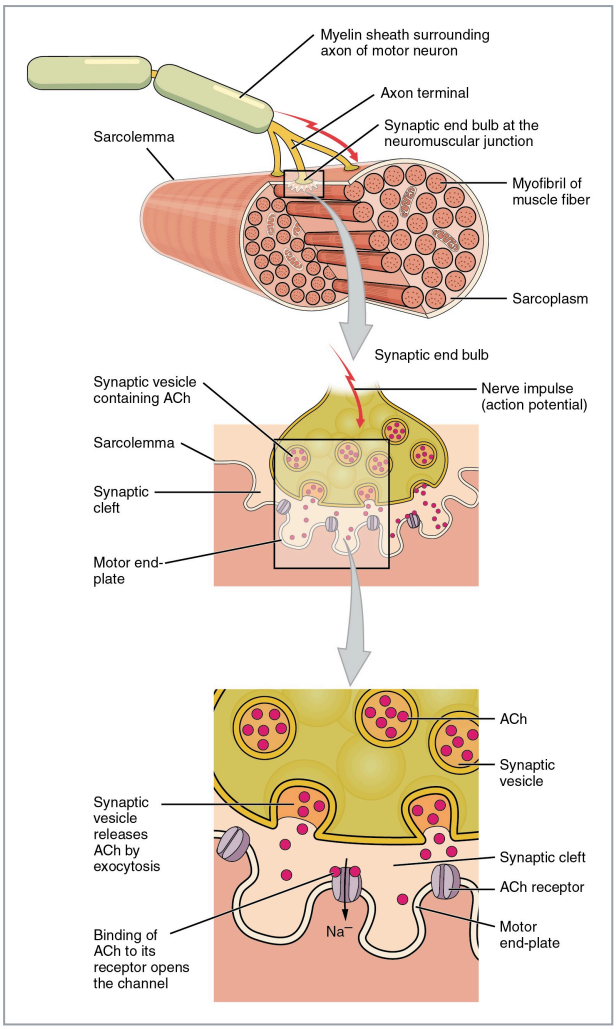
From large to small: **muscle → fascicle → muscle fibre (cell) → myofibril → sarcomere**. Connective tissue (epimysium → perimysium → endomysium) converges to form the **tendon**. The functional unit is the **sarcomere**, built from overlapping **actin** and **myosin** filaments.

3. Muscle Contraction — Sliding-Filament Mechanism



The neuromuscular junction — where the nerve signals the muscle.

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1. A nerve impulse reaches the **neuromuscular junction** and releases acetylcholine.
2. The muscle fibre is excited and calcium (Ca^{2+}) is released.
3. Myosin heads form **cross-bridges** with actin and pull the thin filaments inward.
4. The sarcomere shortens — the muscle contracts (powered by ATP).
5. When stimulation stops, Ca^{2+} is removed and the muscle relaxes.

> **Contraction types.** **Isotonic** (concentric = shortening; eccentric = lengthening under tension) and **isometric** (tension without length change).

> **P&O relevance**
>
> After amputation, residual muscles may weaken or change their line of pull. **Myodesis** and **myoplasty** re-anchor muscles to preserve function. Eccentric control is vital for prosthetic gait, where muscles control deceleration rather than just produce motion.

THEORY · WEEK 11

Major Muscle Groups Overview

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

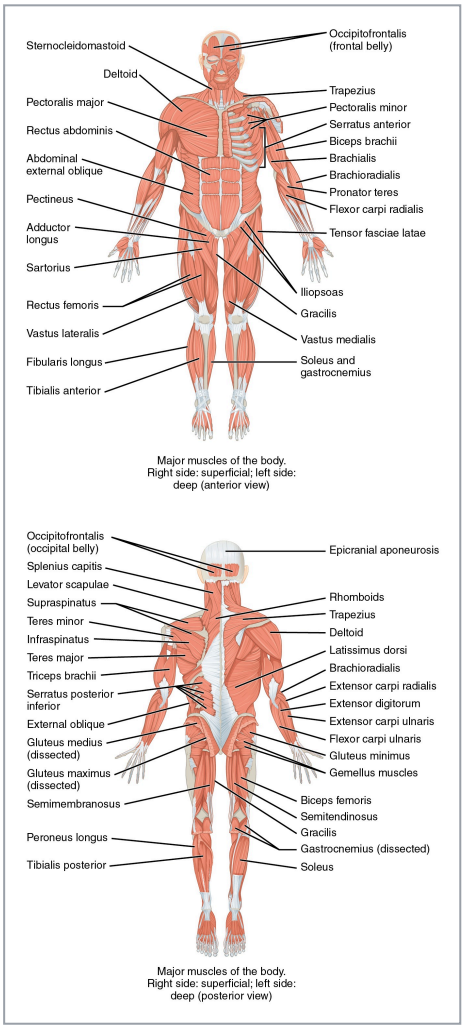
Assist. Lect. Redha Dawood Abdul-Redha · م.م. رضا داود عبد الرضا

Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

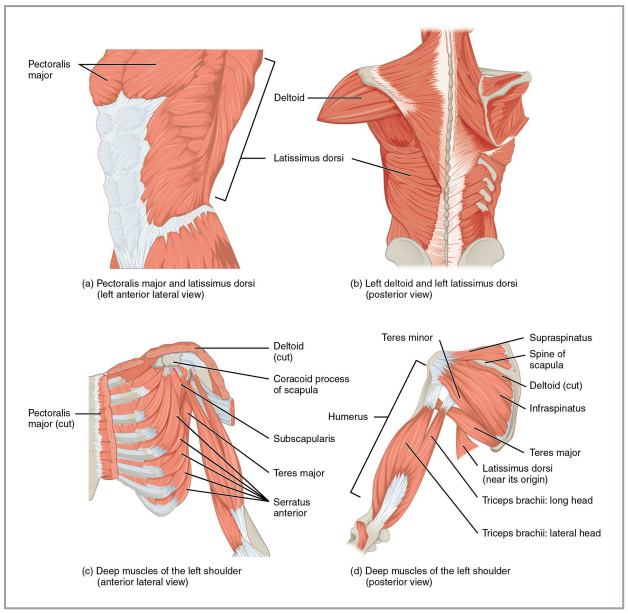
- Locate the major muscle groups of the trunk and limbs.
- State the main action of each group.
- Identify muscle groups most relevant to prosthetic and orthotic function.

1. Overview of the Muscular System



Major superficial muscles of the body.

2. Upper-Limb Muscle Groups



Muscles acting on the humerus.

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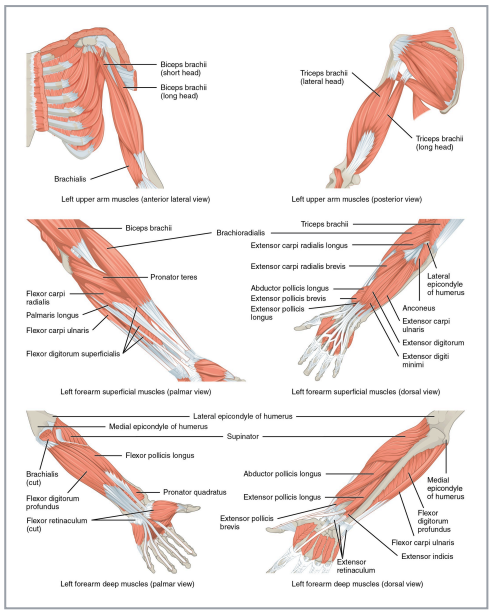

Muscles acting on the forearm.

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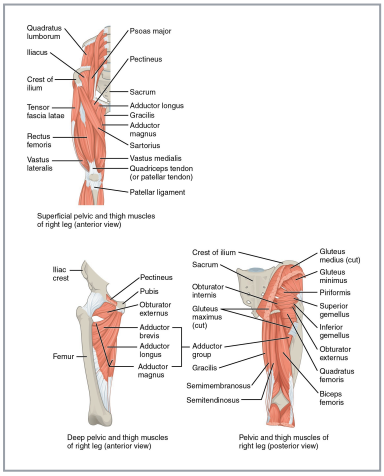
Group	Main action
Deltoid	Abducts the arm
Pectoralis major	Flexes & adducts the arm
Biceps brachii	Flexes the elbow; supinates the forearm
Triceps brachii	Extends the elbow

3. Lower-Limb Muscle Groups



Gluteal muscles (hip).

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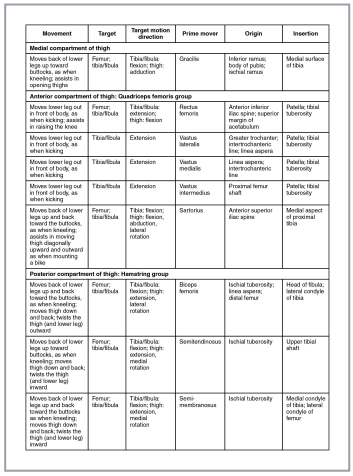

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Medial compartment of thigh					
Moves back of lower legs up toward buttocks; as when kneeling; assists in opening thighs	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: adduction	Gracilis	Inferior ramus; body of pubis; ischial ramus	Medial surface of tibia
Anterior compartment of thigh: Quadriceps femoris group					
Moves lower leg out in front of body, as when kicking; assists in raising the knee	Femur; tibia/fibula	Tibia/fibula: extension; thigh: flexion	Rectus femoris	Anterior inferior iliac spine; superior margin of acetabulum	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus lateralis	Greater trochanter; intertrochanteric line; linea aspera	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus medialis	Linea aspera; intertrochanteric line	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus intermedius	Proximal femur shaft	Patella; tibial tuberosity
Moves back of lower legs up and back toward the buttocks, as when kneeling; assists in moving thigh diagonally upward and outward as when mounting a bike	Femur; tibia/fibula	Tibia: flexion; thigh: flexion, abduction, lateral rotation	Sartorius	Anterior superior iliac spine	Medial aspect of proximal tibia
Posterior compartment of thigh: Hamstring group					
Moves back of lower legs up and back toward the buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) outward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, lateral rotation	Biceps femoris	Ischial tuberosity; linea aspera; distal femur	Head of fibula; lateral condyle of tibia
Moves back of lower legs up toward buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) inward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, medial rotation	Semitendinosus	Ischial tuberosity	Upper tibial shaft
Moves back of lower legs up and back toward the buttocks as when kneeling; moves thigh down and back; twists the thigh (and lower leg) inward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, medial rotation	Semi-membranosus	Ischial tuberosity	Medial condyle of tibia; lateral condyle of femur

Thigh muscles.

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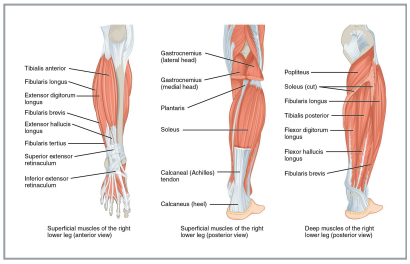

Leg muscles (foot & toes).

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Group	Main action	P&O note
Gluteals	Extend, abduct & stabilise the hip	Stance-phase stability in AK prostheses
Quadriceps femoris	Extends the knee	Patellar-tendon bearing in TT sockets
Hamstrings	Flex the knee; extend the hip	Eccentric control during gait
Gastrocnemius & soleus	Plantarflex the ankle ("push-off")	Replaced by prosthetic foot/ankle
Tibialis anterior	Dorsiflexes the ankle	Weakness → foot drop, treated with an AFO

P&O relevance

Knowing which muscle group produces a movement tells the clinician what is *lost* after amputation or paralysis and what the device must replace. **Foot drop** (weak dorsiflexors) is managed with an **AFO**; loss of calf push-off after trans-tibial amputation is compensated by an energy-storing prosthetic foot.

Quick self-check

1. Which muscle extends the knee, and why does it matter for a TT socket?
2. Which group provides ankle push-off, and how is it replaced after amputation?
3. Name the muscle whose weakness causes foot drop and the orthosis used to manage it.

THEORY · WEEK 12

The Nervous System: CNS & PNS

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

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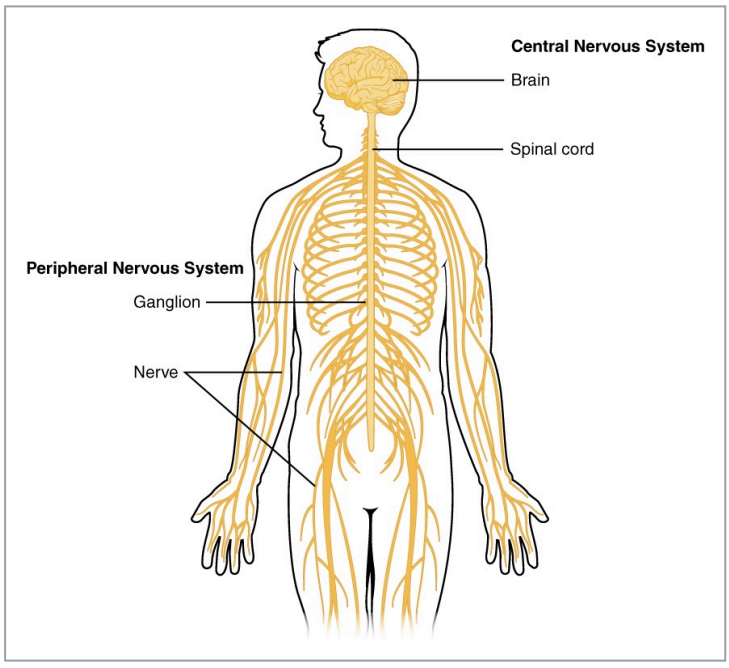
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- Divide the nervous system into CNS and PNS.
- Identify the major regions of the brain and their functions.
- Describe the spinal cord and the structure of a neuron.
- Relate nervous-system function to sensation, motor control and prosthetics.

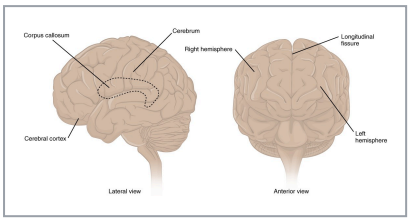
1. Organisation

The nervous system has two divisions: the **central nervous system (CNS)** — brain and spinal cord — and the **peripheral nervous system (PNS)** — cranial and spinal nerves. The PNS is further divided into **somatic** (voluntary) and **autonomic** (involuntary) parts.

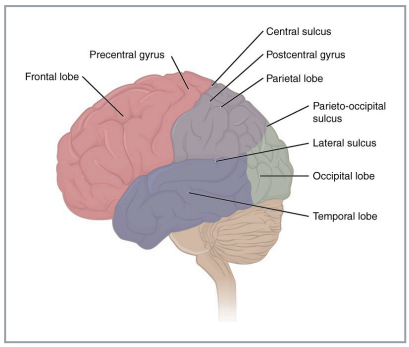


Overview of the central & peripheral nervous systems.

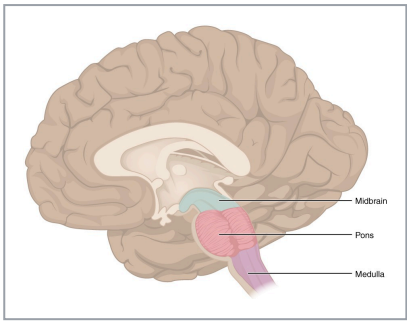
2. The Brain



Cerebrum.



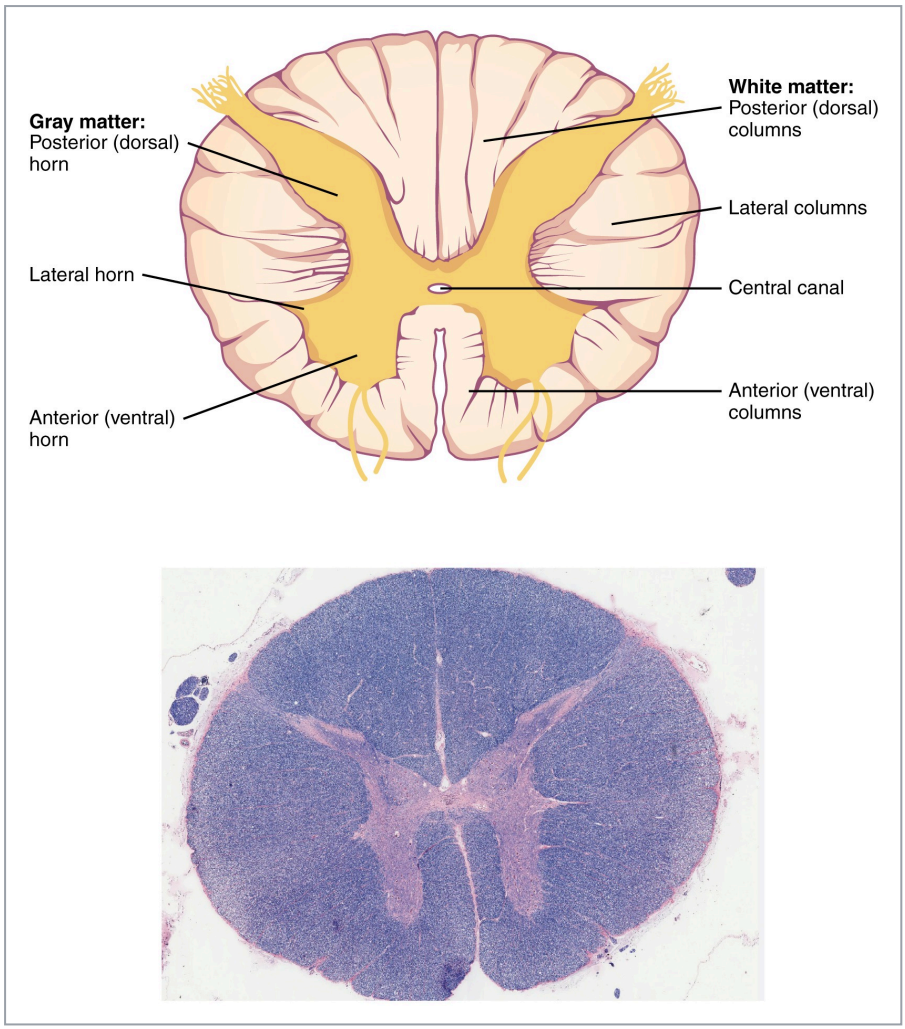
Lobes of the cerebral cortex.



Diencephalon & brain stem.

Region	Main functions
Cerebrum	Voluntary movement, sensation, thought, language (frontal, parietal, temporal, occipital lobes)
Cerebellum	Coordination, balance, fine motor control
Brain stem	Midbrain, pons, medulla — vital reflexes (breathing, heart rate)
Diencephalon	Thalamus (sensory relay) & hypothalamus (homeostasis)

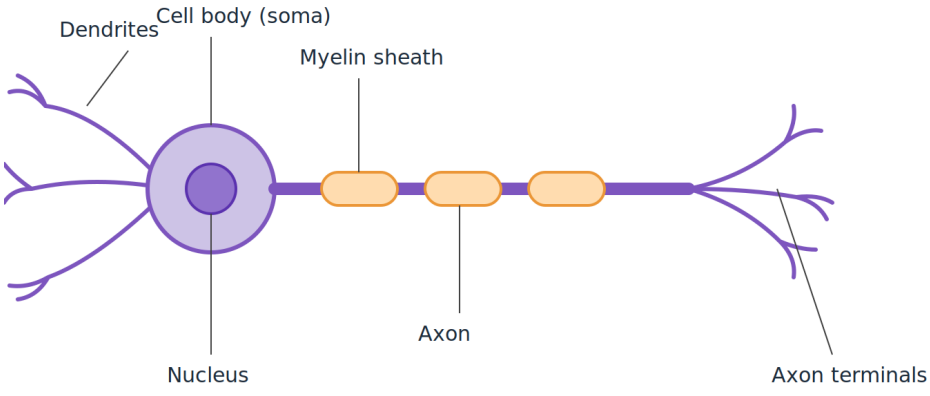
3. The Spinal Cord



Spinal cord in cross-section — grey matter (H-shaped) & white matter columns.

The spinal cord relays signals between brain and body and mediates reflexes. **Grey matter** (central, H-shaped) contains cell bodies; **white matter** (outer) carries ascending sensory and descending motor tracts.

4. The Neuron



Structure of a typical neuron

Structure of a neuron: dendrites, cell body, axon, myelin sheath, axon terminals.

- **Dendrites** receive signals; the **cell body** integrates them.

- The **axon** conducts impulses; the **myelin sheath** speeds conduction.
- **Axon terminals** pass the signal to the next cell at a synapse.

> **P&O relevance**
>
> Nerve injury at an amputation site can cause **neuromas** (painful nerve-end tangles) and **phantom-limb sensation**. CNS conditions (stroke, spinal-cord injury, cerebral palsy) produce the weakness and spasticity that orthoses are designed to manage.

THEORY · WEEK 13

Reflex Arc & Nerve Structure

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

Assist. Lect. Redha Dawood Abdul-Redha · م.م. رضا داود عبد الرضا

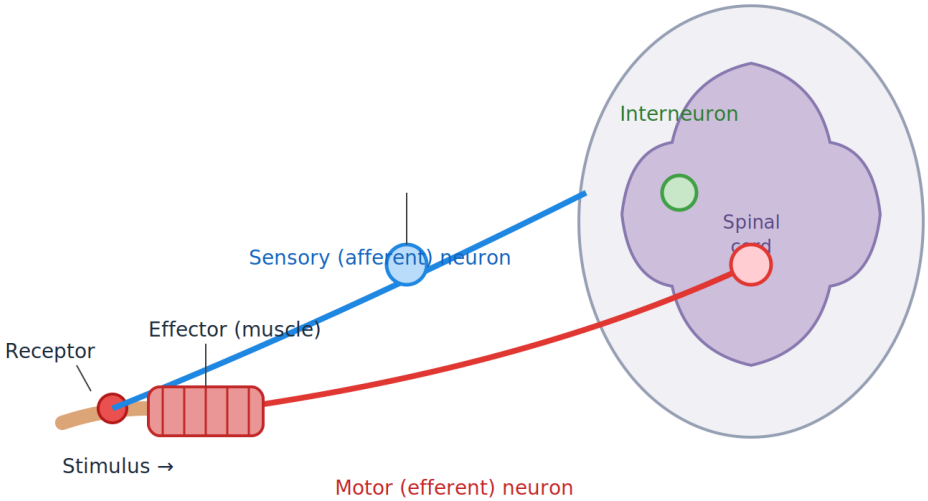
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

Learning objectives

- Define a reflex and list the components of a reflex arc.
- Trace the pathway of a simple spinal reflex.
- Describe the structure of a peripheral nerve.
- Explain the clinical value of reflex testing.

1. The Reflex Arc

A **reflex** is a rapid, automatic, involuntary response to a stimulus. It travels along a **reflex arc** — the neural pathway that allows a response without waiting for the brain.



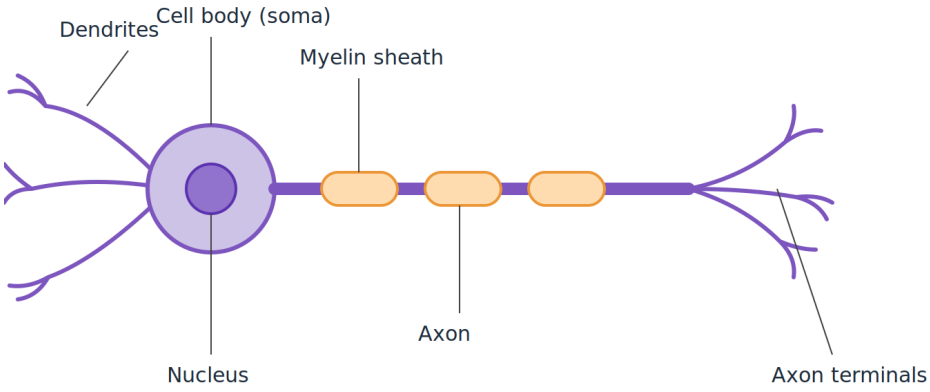
The reflex arc: receptor → sensory neuron → CNS (interneuron) → motor neuron → effector

The five components of a simple reflex arc.

Component	Role
Receptor	Detects the stimulus
Sensory (afferent) neuron	Carries the signal toward the CNS
Integration centre	Spinal cord (± interneuron) processes the signal
Motor (efferent) neuron	Carries the command to the effector
Effector	Muscle or gland that responds

> **Example.** The **patellar (knee-jerk)** reflex: tapping the patellar tendon stretches the quadriceps, triggering a reflexive knee extension — a monosynaptic stretch reflex.

2. Structure of a Peripheral Nerve



Structure of a typical neuron

A neuron — the functional unit bundled within nerves.

A peripheral **nerve** is a cable of many axons. Each axon is wrapped by **endoneurium**; bundles (fascicles) are wrapped by **perineurium**; the whole nerve is wrapped by **epineurium**. Nerves carry sensory (afferent) and/or motor (efferent) fibres.

> **Clinical & P&O relevance**
>
> Reflex testing assesses the integrity of specific spinal levels and peripheral nerves. Absent, reduced or exaggerated reflexes help localise lesions — information that guides orthotic prescription (e.g. spasticity in upper-motor-neuron lesions vs flaccidity in lower-motor-neuron lesions).

Quick self-check

1. List the five parts of a reflex arc in order.
2. Why are reflexes faster than voluntary responses?
3. Name the three connective-tissue layers of a peripheral nerve.

THEORY · WEEK 14

Skin & Fascia (The Integumentary System)

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

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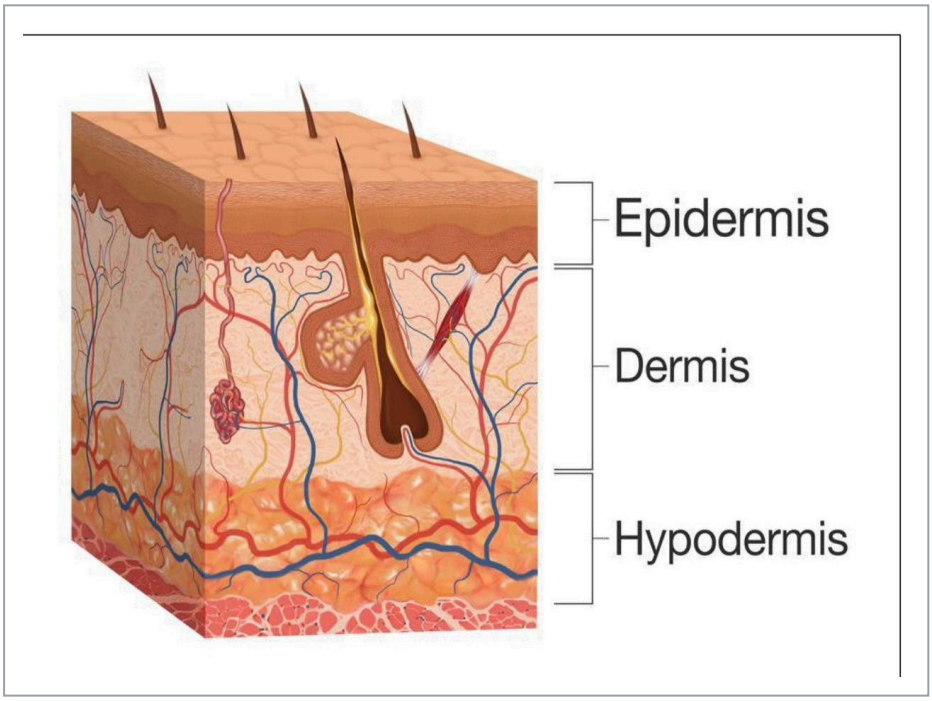
Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

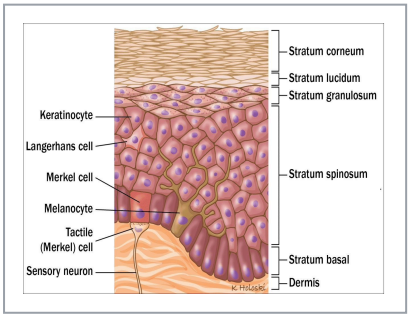
Learning objectives

- Describe the layers of the skin and their components.
- Explain the role of the hypodermis and fascia.
- List the functions of skin and its appendages.
- Relate skin structure to socket fit and pressure management.

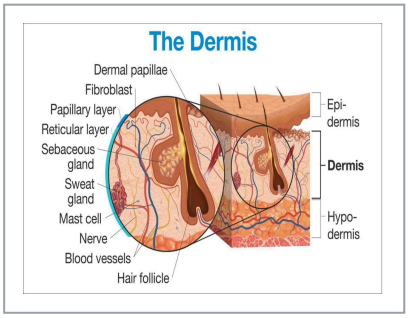
1. Layers of the Skin



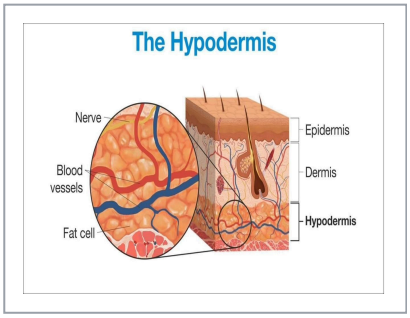
Three-dimensional view of the skin and its layers.



Epidermis (layers).



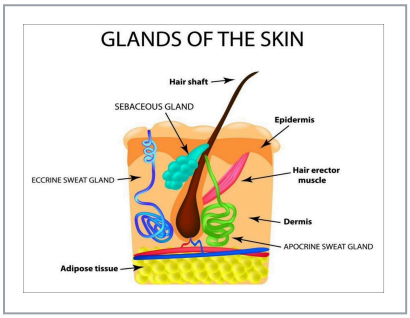
Dermis.



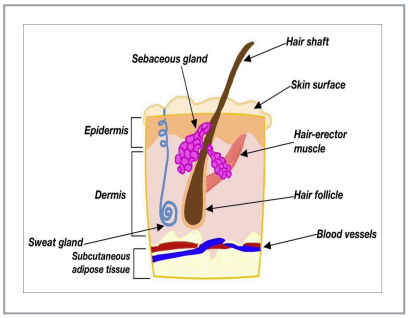
Hypodermis (subcutaneous).

Layer	Features
Epidermis	Outer epithelium; keratinocytes; layered (stratum basale → corneum); waterproof barrier
Dermis	Connective tissue; collagen & elastin; vessels, nerves, glands, hair follicles
Hypodermis (subcutaneous)	Fat & connective tissue; insulation, cushioning, anchors skin to deeper structures

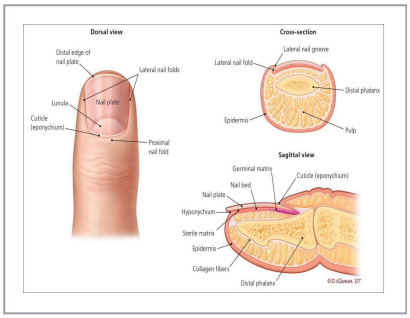
2. Skin Appendages



Sweat & sebaceous glands.



Hair follicle & appendages.



Nail structure.

3. Fascia

Fascia is a sheet of connective tissue beneath the skin. **Superficial fascia** (= hypodermis) stores fat and allows skin mobility; **deep fascia** surrounds muscles, forms compartments and supports neurovascular bundles.

4. Functions of the Skin

Protection (barrier to microbes, chemicals, UV) · **sensation** (touch, pressure, temperature, pain) · **thermoregulation** (sweat, blood flow) · **vitamin D synthesis** · **excretion** of waste in sweat.

> **P&O relevance — the skin is the patient/device interface**
>
> All prosthetic and orthotic loads pass through the skin. Continuous pressure or shear causes **pressure ulcers**; friction causes **blisters**; trapped sweat causes **maceration** and infection. Sockets must distribute load to pressure-tolerant areas, relieve bony prominences, and manage moisture. Intact sensation warns of impending breakdown — a major concern in patients with neuropathy.

Key terms

Epidermis · dermis · hypodermis · **keratinocytes** · **superficial & deep fascia** · **pressure ulcer · shear · maceration**.

THEORY · WEEK 15

Functional Anatomy & Introduction to Biomechanics

Anatomy I — Theory · Department of Prosthetics & Orthotics Technology

Assist. Lect. Redha Dawood Abdul-Redha · م.م. رضا داود عبد الرضا

Specialty: Pathological Analysis Techniques (تقنيات التحليلات المرضية)

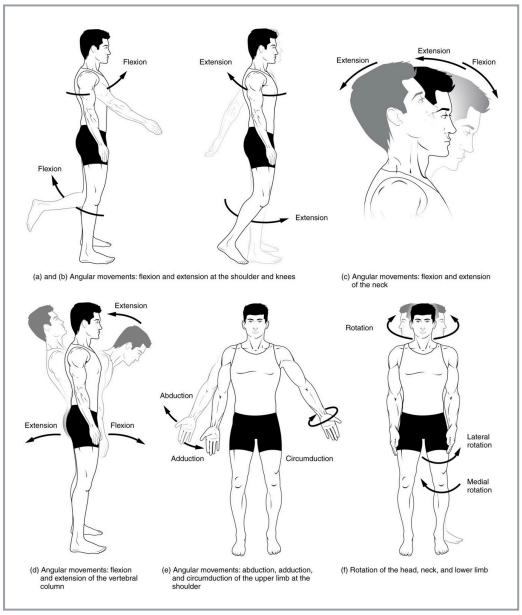
Learning objectives

- Define functional anatomy and biomechanics.
- Describe body movements with correct terminology.
- Relate planes and axes to joint motion.
- Outline the gait cycle and its relevance to P&O.

1. Functional Anatomy & Biomechanics

Functional anatomy studies how structures work together to produce movement; **biomechanics** applies the principles of mechanics (forces, levers, moments) to the living body. Together they explain how muscles, bones and joints generate and control motion — the basis of prosthetic and orthotic design.

2. Body Movements



Angular movements: flexion/extension, abduction/adduction, circumduction, rotation.

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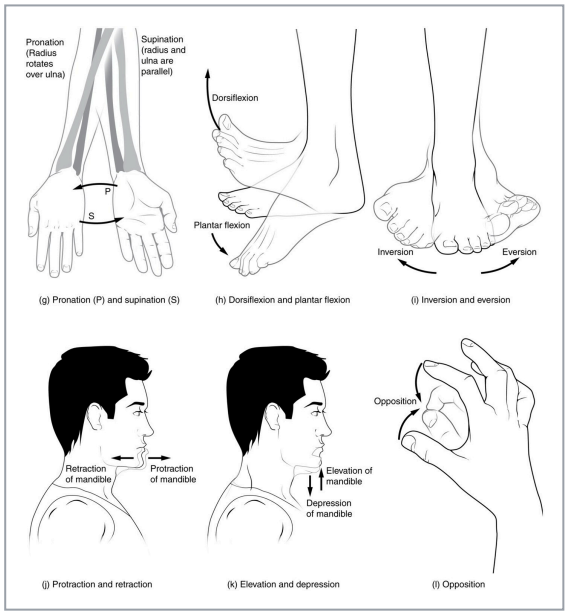

Special movements: pronation/supination, dorsiflexion/plantarflexion, inversion/eversion, opposition.

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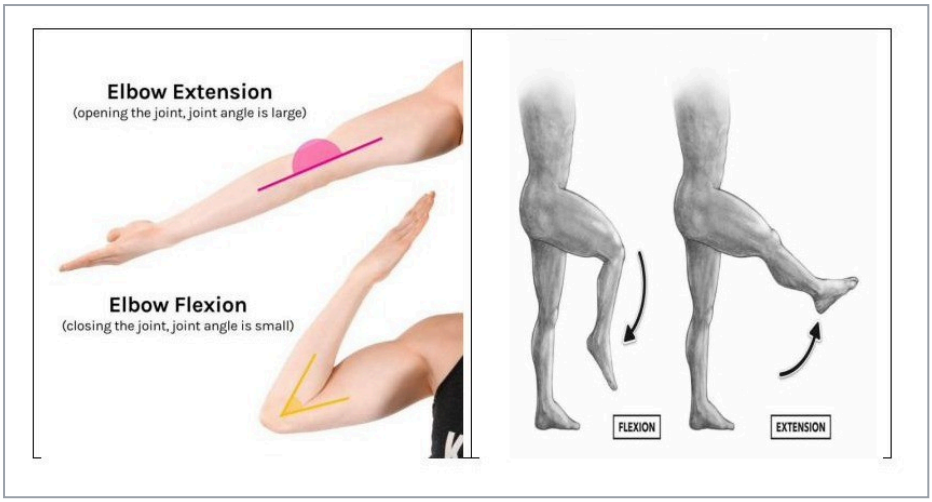

Flexion & extension at the elbow.

3. Planes & Axes of Motion

Plane	Axis	Movements	Example joint
Sagittal	Frontal (medio-lateral)	Flexion / extension	Knee, elbow
Frontal	Sagittal (antero-posterior)	Abduction / adduction	Hip, shoulder
Transverse	Vertical (longitudinal)	Rotation	Hip, neck

4. The Gait Cycle

Walking is described as a repeating **gait cycle** from heel-strike of one foot to the next heel-strike of the same foot, with two phases:

- **Stance phase (~60%)** — foot on the ground: heel-strike → foot-flat → mid-stance → heel-off → toe-off.
- **Swing phase (~40%)** — limb advances: initial swing → mid-swing → terminal swing.

> **P&O relevance — putting it all together**
>
> Every prosthesis and orthosis is a biomechanical solution. Understanding which muscles act, in which plane, about which joint axis, during which phase of gait lets the clinician choose components and alignment that restore safe, efficient movement. This is where the whole of Anatomy I converges on professional practice.

Quick self-check

1. Match each plane to its axis and a sample movement.
2. List the events of the stance phase in order.
3. Give one example of how a muscle group's action is replaced or supported by a P&O device.