AXIAL VERSUS APPENDICULAR. The trunk wall is organized as a series of segmental stripes. Each stripe consists of several layers including skin, subcutaneous tissue, deep fascia, muscles, bones, joints, and parietal pleura or parietal peritoneum. The segmental organization of the trunk is very apparent in the thorax where the boundaries between adjacent stripes are demarcated by ribs. In the abdomen, the same segmental arrangement continues even though the boundaries between stripes are indistinct. The nerves of the trunk wall are also segmental in organization. Although there is some overlap, the spinal nerves from one spinal cord segment provide motor and sensory innervation to one segmental stripe.

This segmental pattern is altered in the limbs during embryonic development. Each limb in the adult is organized as a sequence of morphologically different limb elements rather than as a series of morphologically similar elements. The major nerves of the limbs, formed in the brachial plexus and lumbosacral plexus, contain input from several spinal cord segments rather than a single spinal cord segment. The bones of the trunk and limbs are contrasted in Figure 1; the nerves of the trunk and limbs are contrasted in Figure 2.

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Figure 1. Bones of the trunk and limbs.

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**Cutaneous Innervation**

1. Cervical plexus branches
2. Brachial plexus branches
3. Segmental ventral primary rami
4. Lumbosacral plexus brr.

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*Figure 2.* Cutaneous nerves of the trunk and limbs.
Limb regions

Limb regions often have the same names as the underlying joints (Figure 3). Terms for regions and joints can be confusing unless they are used precisely. The terms ‘upper limb’ and ‘arm’ are not equivalent. The terms ‘leg’ and ‘lower limb’ are not equivalent.

The region where the limb attaches to the trunk is the
- Shoulder in the upper limb and the
- Hip in the lower limb.

The region where the proximal and distal limb segments meet is the
- Elbow in the upper limb and the
- Knee in the lower limb.

The distal limb segment is the
- Antebrachium (forearm) in the upper limb and the
- Crus (leg) in the lower limb.

The manus (hand) and pes (foot) attach to the distal limb segment at the
- Carpus in the upper limb and the
- Tarsus in the lower limb.

The region where the proximal and distal limb segments meet is the
- Elbow in the upper limb and the
- Knee in the lower limb.

The distal limb segment is the
- Antebrachium (forearm) in the upper limb and the
- Crus (leg) in the lower limb.

The manus (hand) and pes (foot) attach to the distal limb segment at the
- Carpus in the upper limb and the
- Tarsus in the lower limb.

Distally, the limbs end at the
- Hand (manus) in the upper limb and the
- Foot (pes) in the lower limb.

The hand and foot bear digits. The fingers are the upper limb digits; the toes are the lower limb digits. Some upper and lower limb digits have special names.
- The thumb (pollux) is the first digit of the hand. The remaining digits are numbered 2-5.
- The great toe (hallux) is the first digit of the foot. The remaining digits are numbered 2-5.
- The fifth digit is the digitus minimus or digitus quintus.

The Latin words ‘digitorum’, ‘pollicis’, ‘hallucis’, and digit minimi mean ‘of the digits’, ‘of the thumb’, ‘of the great toe’ and ‘of the little finger’ respectively. The cubital fossa is a space formed by the muscles anterior to the elbow. The popliteal fossa is a space between the muscles posterior to the knee joint.
**Upper limb regions**

1. **Shoulder**
2. **Brachium (arm)**
3. **Antebrachium (forearm)**
4. **Wrist (wrist)**
5. **Manus**
6. **Digits (hallux, 2-5)**

**Lower limb regions**

1. **Hip**
2. **Thigh**
3. **Crus**
4. **Tarsus (ankle)**
5. **Pes (foot)**
6. **Digits (hallux, 2-5)**

*Figure 3.* Limb regions.
**Terminology.** In the limbs, the term ‘proximal’ means nearer to the midline of the trunk and the term ‘distal’ means farther from the trunk midline. Most anatomical descriptions of the limbs assume that the body is in standard anatomical position (SAP). In standard anatomical position (SAP), the palmar (volar) surface of the hand faces anteriorly and the plantar (volar) surface of the foot faces interiorly. In SAP, the pollex is lateral to the other fingers and the hallux is medial to the other toes.

Since the upper limb is seldom in standard anatomical position, the terms ‘radial’ and ‘ulnar’ may be sensibly interchanged for ‘lateral’ and ‘medial’.

**Superficial layers of the upper limb**

The superficial layers of the limbs include skin and subcutaneous connective tissue (superficial fascia, hypodermis) (Figure 4).

**Skin.** Except for the thick, glabrous (hairless) skin of the palmar surface of the hand and plantar surface of the foot, the skin of the limbs is relatively thin and mobile. Sensation from the dermatomes of the limbs travels in cutaneous branches of the mixed nerves of the limbs. Each of these mixed nerves carries motor and sensory fibers from several spinal cord segments.

**Subcutaneous connective tissue.** The subcutaneous tissue of the limbs consists of loose connective tissue. The proportions of adipocytes and collagen strands within this subcutaneous tissue varies according to local functional requirements. The subcutaneous connective tissue over the palmar surface of the hand and plantar surface of the foot includes many densely interwoven collagen strands which anchor the skin firmly to the underlying tissues. In other regions not subject to strong shear forces, the subcutaneous tissue consists of numerous adipocytes and scarce collagen strands.

Cutaneous nerves travel within the subcutaneous connective tissue to reach the skin. The blood supply to the skin and subcutaneous tissues is usually derived from branches of arteries supplying the underlying muscle tissue.

**Superficial veins.** Blood from superficial layers in both limbs drains into large superficial veins (Figure 4). Unlike the deeper veins of the limbs, the superficial veins have no arterial counterparts. The superficial veins—one long vein and one short vein—arise from the dorsal venous arches of the hand and foot and drain into deep veins. The long superficial vein of the upper limb (cephalic vein) begins at on the radial side of the dorsal venous arch and runs proximally to join the axillary vein at the shoulder. The short superficial vein of the upper limb (basilic vein) begins at the dorsal venous arch on the ulnar side of the hand and runs proximally to join the brachial vein proximal to the elbow. The median cubital vein bridges the cephalic and basilic veins and provides a commonly used venipuncture site.
Bones and deep fascia of the upper limb

Limb bones. Bone is a metabolically active tissue, and bone is continually remodeling. Bone generally heals more quickly and thoroughly than connective tissue or cartilage.

The shape of a bone is determined by its functions.

- Most limb bones are elongated levers or supports (Figure 5). The bones of the carpus and tarsus are chunks of bone.
- The articular ends of bones meet other bones at joints. The geometry of the articular ends of the bones meeting at a joint helps determine the motion(s) permitted at that joint.
- The muscles attaching to a bone sculpt the surface of the bone at their attachment sites, forming conspicuous landmarks. Tuberosities, tubercles, lines, trochanters, and epicondyles are all bony prominences elevated by muscle attachments.

Figure 4. Superficial layers of the brachium and antebrachium, axial section.
Upper limb bones

Shoulder girdle
1. Clavicle
2. Scapula
3. Humerus
4. Antebrachium
5. Radius
6. Ulna
7. Carpus (wrist)
8. Carpals*
9. Manus (hand)
10. Metacarpals
11. Digits (pollux, 2-5)
12. Phalanges

*Proximal row: scaphoid, lunate, triquetrum, pisiform
Distal row: trapezium, trapezoid, capitale, hamate

Figure 5. Bones of the upper limb.
Deep fascia. The variety of the regional names applied to the deep fascia of the limbs obscures the fact that deep fascia surrounds both limbs as a continuous dense connective tissue sheath from the trunk to the tip of the digits (Figure 6). Deep fascia adheres to bones and ligaments where they appear superficially at joints. Where large muscle groups intervene between deep fascia and bone, the deep fascia surrounds the major muscle groups of the limbs and separates them by forming fascial septa attaching to the periosteum of the underlying bones.

The compartments formed by the deep fascia in the limbs are the key to understanding the organization of the limbs. Muscles within a compartment share many similar functions, motor innervation, and blood supply.

Deep fascia also forms interosseous membranes which are thick dense connective tissue sheets between the shafts of the radius and ulna in the antebrachium and between the tibia and fibula in the crus. The deep fascia of the limbs also thickens considerably around the wrist and ankle, forming retinacula that prevent tendon ‘bowstringing’ during muscular contraction.

Figure 6. Bones and fascia of the upper limb, axial section.
**MUSCLES AND JOINTS**

**Upper limb joints.** All normal motions in the limbs occur at joints (Figure 7).

- The motions permitted at a joint are determined by
  - The geometry of the articular ends of the bones meeting at a joint.
  - Menisci or discs refining bone congruence.
  - Ligaments and tendons crossing the joint and restricting unwanted motions.

*Figure 7.* Motions possible at joints.
The motions permitted at a joint are best understood as motion pairs (Figure 7).

- **Flexion and extension.** In flexion, the bones meeting at a joint are drawn closer together and the angle formed by the bones becomes more acute. In extension, the bones meeting at a joint move farther apart and the angle formed by the bones becomes more obtuse.

- **Abduction and adduction.** In abduction, a limb or limb segment moves farther from the trunk midline. In adduction, a limb or limb segment moves closer to the trunk midline. Abduction at the wrist joint (in SAP) is radial deviation; adduction of the wrist joint is ulnar deviation. Eversion at the subtalar joint is a combination of foot abduction and turning the sole of the foot outward. Inversion at the subtalar joint is a combination of foot adduction and turning the sole of the foot inward.

- **Medial rotation and lateral rotation.** Limb rotation is motion around the long axis of the limb. In medial rotation, the anterior surface of a limb or limb segment rotates toward the trunk midline. In lateral rotation, the anterior surface of the limb or limb segment rotates away from the trunk midline. Pronation is medial rotation of the forearm; supination is lateral rotation of the forearm.

The joints of the upper limb are adapted primarily for mobility; the joints of the lower limb are adapted primarily for stability.

The joints of the upper limb, and the motions possible at each joint, are summarized in Figure 8.

**Upper limb muscles.** Muscles contract. The position of a muscle relative to a joint determines the motion(s) produced at that joint by contraction of the muscle. Knowledge of the motions possible at a joint, and knowledge of which joint surfaces a muscle crosses, enable reliable inferences about muscle function without excessive reliance of stultifying descriptions of muscle attachments. (Figure 8).

**Compartments of the upper limb**

Muscles in a limb compartment share functions, innervation and blood supply. Muscles within a compartment cross the joints proximal and/or distal to the compartment limb. The key to understanding the organization of the limbs is the arrangement of muscles and neurovascular bundles within fascially limited compartments.
**UPPER LIMB JOINTS**

1. Sternoclavicular
2. Scapula on trunk [Gliding]
3. Shoulder (scapula, humerus) F/E, Ab/Ad, LR/RR
4. Elbow (humerus, radius, ulna) F/E
5. Proximal radioulnar LR/RR
6. Distal radioulnar LR/RR
7. Wrist (radius, scaphoid, lunate) F/E, Ab/Ad
8. Intercarpal
9. Carpometacarpal F/E, Ab/Ad (1st only)
10. Metacarpophalangeal F/E
11. Proximal interphalangeal F/E
12. Distal interphalangeal F/E

*Proximal row: scaphoid, lunate, triquetrum, pisiform
Distal row: trapezium, trapezoid, capitate, hamate

**Figure 8.** Limb joints and motions.
**MUSCLES AND FUNCTIONS**

*Muscles crossing the flexor surface of the shoulder joint*
- Coracobrachialis
- Biceps brachii, long head

*Muscles crossing the flexor surface of the elbow joint*
- Biceps brachii
- Brachialis

Muscles crossing the supinator surface of the proximal radioulnar joint
- Biceps brachii

**INNERVATION AND PREDOMINANT BLOOD SUPPLY**
- Musculocutaneous nerve
- Brachial vessels

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*Figure 9.* Anterior compartment of the brachium.
**Muscles and Functions**

*Muscles crossing the extensor surface of the shoulder joint*

- Triceps brachii, long head

*Muscles crossing the extensor surface of the elbow joint*

- Triceps, brachii

**Innervation and Predominant Blood Supply**

- Radial nerve
- Profunda brachii vessels
Figure 11. Bones and deep fascia of the antebrachium.

1. Skin
2. Subcutaneous fat
3. Cephalic v.
4. Basilic vein
5. Cutaneous nerves and vessels
Figure 12. Bones and deep fascia of the antebrachium.

**ANTEBRACHIUM**

**BONES AND DEEP FASCIA**

1. Radius
2. Ulna
3. Interosseous membrane
4. Antebrachial fascia
5. Anterior antebrachial compartment
6. Posterior antebrachial compartment
Anterior antebrachial compartment

1. Palmaris longus muscle
2. Flexor carpi radialis
3. Flexor carpi ulnaris
4. Flexor digitorum superficialis
5. Flexor digitorum profundus
6. Flexor pollicis longus
7. Pronator teres
8. Median nerve
9. Ulnar nerve
10. Ulnar vessels
11. Anterior interosseous nerve
12. Anterior interosseous vessels

Figure 13. Superficial layers of the brachium and antebrachium.
MUSCLES AND FUNCTIONS

Muscles crossing the flexor surface of the elbow joint
- Palmaris longus
- Flexor carpi radialis
- Flexor carpi ulnaris
- Flexor digitorum superficialis

Muscles crossing the flexor surface of the wrist joint
- Palmaris longus
- Flexor carpi radialis
- Flexor carpi ulnaris
- Flexor digitorum superficialis
- Flexor digitorum profundus
- Flexor pollicis longus

Muscles crossing the flexor surfaces of the digits
- Flexor digitorum superficialis (to PIP)
- Flexor digitorum profundus (to DIP)
- Flexor pollicis longus (to DIP)

Muscles crossing the abductor (radial deviation) surface of the wrist joint
- Flexor carpi radialis

Muscles crossing the adductor (ulnar deviation) surface of the wrist joint
- Flexor carpi ulnaris

Muscles crossing the pronator surface of the proximal radioulnar joint
- Pronator teres

Muscles crossing the pronator surface of the distal radioulnar joint
- Pronator quadratus

INNERVATION AND PREDOMINANT BLOOD SUPPLY
- Median nerve (all anterior antebrachial compartment muscles except FCU and FDP tendons 3 and 4)
- Ulnar nerve (FCU and FDP tendons 3 and 4)
- Radial vessels
- Ulnar vessels
**ANTEBRACHIUM**

**Posterior Antebrachial Compartment**

1. [Anconeus muscle]*
2. Brachioradialis muscle
3. Extensor carpi radialis longus muscle
4. Radial nerve
5. Radial vessels
6. Extensor carpi radialis brevis muscle
7. Extensor digitorum muscle
8. Extensor digiti minimi muscle
9. Extensor carpi ulnaris muscle
10. [Supinator muscle]*
11. Extensor indicis muscle
12. Extensor pollicis longus muscle
13. Extensor pollicis brevis muscle
14. Abductor pollicis longus muscle
15. Posterior interosseous nerve
16. Posterior interosseous vessels

*Superior to plane of section

**Figure 14.** Posterior antebrachial compartment.
POSTERIOR ANTEBRACHIAL COMPARTMENT

MUSCLES AND FUNCTIONS

Muscles crossing the flexor surface of the elbow joint
- Brachioradialis

Muscles crossing the extensor surface of the wrist joint
- Extensor carpi radialis
- Extensor carpi ulnaris
- Extensor digitorum
- Extensor indicus
- Extensor digitorum minimi

Muscles crossing the extensor surfaces of the digits
- Extensor digitorum superficialis
- Extensor digitorum profundus
- Extensor pollicis longus

Muscles crossing the abductor (radial deviation) surface of the wrist joint
- Extensor carpi radialis
- Extensor pollicis longus
- Extensor pollicis brevis
- Abductor pollicis longus

Muscles crossing the adductor (ulnar deviation) surface of the wrist joint
- Extensor carpi ulnaris

Muscles crossing the supinator surface of the proximal radioulnar joint
- Supinator

INNERVATION AND PREDOMINANT BLOOD SUPPLY
- Radial nerve and posterior interosseous branch of radial nerve
- Posterior interosseous vessels (branches of ulnar vessels)
Nerves and vessels of the upper limb

Innervation of the upper limb. The somatic motor and sensory innervation to the limbs are derived from somatic plexuses formed by the ventral primary rami of spinal nerves (brachial plexus or lumbosacral plexus). Five branches of the brachial plexus supply the upper limb (Figure 15); four branches of the lumbosacral plexus supply the lower limb.

Blood supply of the upper limb. The basic plan for the arterial blood supply to the upper and lower limbs is quite similar. Very generally, the sequence of arteries in the limbs is

- A single large artery (subclavian -> axillary -> brachial in the upper limb) forming an anastomotic loop around the bone in the proximal limb segment.
- Two medium sized arteries (radial and ulnar in the upper limb) in the limb segment with the two medium-sized bones.
- Arches at the level of the metacarpals or metatarsals formed by the medium sized arteries (superficial and deep palmar arches in the upper limb).
- Branches of the arches accompanying the digits.
- Anastomoses around all joints formed by arteries proximal and distal to the joints.
Figure 15. Major branches of the brachial plexus.
**Upper Limb Vessels**

Superficial veins
1. Cephalic v.
2. Basilic vein

Deep vessels
3. Subclavian vessels (continue as)
4. Axillary vessels (continue as)
5. Circumflex vss.
6. Brachial vessels
7. Deep brachial vessels
8. Radial vessels
9. Ulnar vessels
10. Superficial plantar arch
11.

**Figure 16.** Superficial veins, arteries and deep veins of the upper limb.