The hand, located at the extremity of the upper body, is a very versatile tool.

This is due to the enormous mobility of the fingers, which are equipped with a complex system of tendons—witness the hands of a pianist, for example.

The other factor contributing to the hand's versatility is the arrangement of the thumb vis-à-vis the fingers. The opposable thumbs makes it possible to grasp objects and to accomplish many different tasks, ranging from fine precision (threading a needle) to great strength (lifting a heavy object, pulling on a partner).

The hand is linked to the forearm via the carpal bones, which form the area of the wrist. In this chapter, we will describe the wrist and hand together since they share many muscles.

Because the thumb plays such a major role in the bone and muscle structure of the hand, it will be dealt with separately at the end of the chapter.
Landmarks

[ANTERIOR (PALMAR) VIEW]

radial styloid process
thenar eminence*
wrist crease (flexion)
interphalangeal creases (flexion)
ulnar styloid process
hypotenar eminence**
palmar depression
metacarpophalangeal crease

*formed by the intrinsic muscles of the thumb
**formed by the intrinsic muscles of the little finger

[POSTERIOR (DORSAL) VIEW]

carpal region
metacarpal region
phalangeal region
wrist crease (extension)
extensor tendons
metacarpophalangeal joints (knuckles)
interphalangeal creases (extension)
Bones

The skeleton of the hand, shown here with the palm facing forward, consists of three bony areas:

At the top are the **carpal bones**, consisting of eight small bones. The carpals are arranged in two rows of four bones each.

The first row connects with the bones of the forearm.

The second row connects with the metacarpal region, which consists of five long bones or **metacarpals**, which flare out and form the skeleton of the palm.

Each metacarpal connects with **phalanges**. The thumb has two, the other fingers three. The phalanges make up the skeleton of the fingers.

The metacarpals and phalanges flare out like a fan.
Movements of the wrist

In **flexion** of the wrist, the palm moves closer to the anterior surface of the forearm.

The fingers tend to stretch during this movement, due to tightening of the extensor tendons.

You can feel this tightening on the back of the hand when flexing the fingers.

In **extension** of the wrist, the posterior surfaces of the hand and forearm move closer together.

In this case, the fingers tend to flex, due to tightening of the flexor tendons.

You can feel these tendons on the palm when extending the fingers.

Flexion and extension of the wrist have roughly the same range of motion.
In **abduction** (or radial deviation), the angle formed by the lateral borders of the hand and forearm decreases, i.e., the thumb moves closer to the radius.

In **adduction** (or ulnar deviation), the angle formed by the medial borders of the hand and forearm decreases, i.e., the little finger moves closer to the ulna.

The range of motion for adduction is greater than that of abduction.

The wrist and hand usually move in an oblique direction.

Because of the muscles involved, adduction tends to be combined with flexion...

...whereas abduction tends to occur together with extension.

[Movements of the fingers are described on p. 169.]
Carpal bones

The wrist, which is only 3cm in height and 5cm in width, consists of two rows, each containing four bones.

At the top, the "radiocarpal" row articulates with the forearm.

The scaphoid articulates superiorly with the radius and inferiorly with the trapezium and trapezoid.

The lunate articulates superiorly with the radius and articular disc and inferiorly with the capitate.

The triquetrum articulates superiorly with the articular disc. Inferiorly, it contacts the hamate and capitate.

The pisiform is a small round bone which sits on the anterior surface of the triquetrum. It does not articulate with the forearm nor with the hamate, but does serve for attachment of some ligaments.

The trapezium has a sharp anterior crest. It joins metacarpal I.

The trapezoid is the most symmetrical of the carpal bones, being shaped like a pyramid with the top cut off. It articulates with metacarpal II.

The capitate is the largest carpal and has an anterior tubercle. It articulates primarily with metacarpal III and has two facets on the inferior corners which contact metacarpals II and IV.

The hamate has a prominent anterior projection called the "hook." The inferior surface of the hamate has two facets oriented in different directions which articulate with metacarpals IV and V.
The wrist consists of small bones which articulate with each other laterally. All the surfaces are covered by cartilage.

There are many small ligaments binding the carpals to one another and to the metacarpals.

**Carpal arch**

There are eight carpal bones. Together, the carpals form an anteriorly-concave arch.

...and medially of the triquetrum, pisiform, and hamate.

Because of the annular (or transverse carpal) ligament which runs anterior to the carpus, this concave space is transformed into a tunnel, the **carpal tunnel**.

The small intrinsic muscles of the hand and palmaris longus attach above this ligament. The tendons of the long muscles of the hand pass below it.

Superiorly, the scaphoid, lunate, and triquetrum present a large convex surface which articulates with the smaller concave surface presented by the distal radius and articular disc to form an ellipsoid joint.

The posterior surface is convex and the bones are bound together here, like on the anterior surface, by many ligaments.
Articular surfaces of wrist joint

The wrist is an articular region consisting of many bones arranged in two rows:

- At the top, the radius and the articular disc (forming the articular radiocarpal surface) articulate with the proximal row of carpal bones (except the pisiform). This is called the **radiocarpal joint**.

- Below, this proximal row articulates with the second row of carpal bones. This is called the **midcarpal joint**.

The **articular disc** maintains the wrist structure during pronation and supination. If the wrist were to directly articulate with the two bones of the forearm, it would fold on itself during pronation.

Through the articular disc, the wrist forms a quasi-continuous surface with the radius, whether the forearm is pronated or supinated. During both movements, it “wipes” the ulnar head like a windshield wiper.

Radiocarpal joint

The surface of the radiocarpal articulation has a concave oval shape, whose posterior edge is slightly lower than the anterior edge.

Laterally, it consists of the inferior surface of the radius, and medially of the inferior surface of the articular disc, covered by cartilage.

Midcarpal joint

The midcarpal joint consists of the inferior surfaces of the scaphoid, lunate, and triquetrum proximally, and the superior surfaces of trapezium, trapezoid, capitate, and hamate distally.

The superior surfaces of the scaphoid and lunate bones, considered together, are the **carpal condyle**, which articulates with the radius. These surfaces are covered with cartilage.

The space between the two rows has the shape of the letter S, where we can distinguish two parts:

- an internal part, which consists of a concave and a convex surface

- an external part, which consists of two flat surfaces superiorly and inferiorly.
Joint capsules

The radiocarpal joint is surrounded by a capsule, which is attached to the joint circumference. It is very loose from front to back, but taut laterally. It is lined by a synovial membrane. There is an articular capsule at each midcarpal joint. The capsules are more or less joined to each other and the synovial membrane is continuous (not shown).

Ligaments

The radiocarpal joints have many small ligaments, which can be subdivided into three groups:

- **anterior ligaments**
  run from the anterior surface of the distal radius to the carpal bones

- **lateral ligaments**
  run from the styloid processes of the radius and ulna to the carpal bones

- **posterior ligaments**
  run from the posterior surface of the distal radius and the articular disc to the carpal bones.

The ligaments at the midcarpal joints connect neighboring bones. They are reinforced by bundles of ligaments from the radiocarpal joint.
Movements of the wrist

The movements of the wrist involve two rows of joints.

Wrist flexion is primarily a function of the radiocarpal joint.

Extension involves the midcarpal joint to a greater extent, since the posterior border of the distal radius limits extension at the radiocarpal joint.

In abduction, the scaphoid moves closer to the radius. This movement is limited by the radial styloid. Medially, the proximal and distal rows of carpals move apart.

The proximal carpal row goes into flexion-pronation...

...while the distal row goes into extension-supination.

In adduction, the triquetrum moves closer to the ulna, while the scaphoid moves away from the radius.

Movement is less restricted here because the ulnar styloid is not as prominent as the radial styloid. The lateral carpals move apart during adduction.
Metacarpals and phalanges

There are five bony structures which consist of one metacarpal and several phalanges each (the thumb has two phalanges, the other fingers have three each).

Each of these bones consists of three parts:

- **base (proximal)**

The bony structures studied here are those of fingers 2 through 5. The structure of the thumb is studied on page 183.

- **shaft**

The base of each metacarpal is roughly quadrangular, with facets for articulation with a carpal and the adjacent metacarpals.

The shaft is roughly triangular, with three surfaces and three sides.

- **head (distal)**

The head has one cartilaginous articulating surface, which is rounded from front to back and laterally. On each side, there is a small tubercle.

The metacarpals

The proximal phalanx of each finger has a concavely rounded base for articulation with the metacarpal, and a pulley-shaped head.

The middle phalanx is concave but with a median crest to match the shape of the head of the proximal phalanx. The head has the same surface as the proximal phalanx.

The base of the distal phalanx is identical to the base of the second phalanx. Its palmar head has a protuberance for the finger tip area.
Carpometacarpal joints
(without thumb)

These are the joints between the distal row of carpals and the metacarpals.

The articular surfaces are straight. They allow slight sliding/gliding and flexion/extension movements.

The range of these movements increases progressively from metacarpal II through V.

As a result of the anterior curvature of the carpals, the plane of carpometacarpal joints IV and V is oblique to that of joints II and III.

Thus, metacarpals IV and V can flex, which moves them toward the thumb. It is the carpometacarpal movements as a whole which bring about the anterior depression of the hand.

This depression is made complete by the opposition of the thumb.
Metacarpophalangeal joints

[The third finger serves as the example here.]

These are essentially hinge joints, allowing:

- Flexion/extension...
- Abduction/adduction...
- And rotation.

The joint capsule is slack at the front and back, taut at the sides, and reinforced on the palmar surface by the palmar ligament, a dense band of fibrocartilaginous tissue. This ligament attaches to the edge of the phalanx and forms a hinge there.

When the joint is extended, the ligament stretches over the surface of the phalangeal base.

When the joint is flexed, it folds due to its hinge-like structure and the folds of the capsule.

The capsule is reinforced by collateral ligaments which run from the tubercle of the metacarpal head to the lateral sides of the base of the phalanx. Since they originate from the dorsal side of the metacarpal head, which is somewhat narrower than the palmar side, these ligaments are slack in extension and taut in flexion.

Consequently, movements of abduction/adduction and rotation are impossible when the joint is in full flexion.

When the metacarpophalangeal joints are in extension or slight flexion, passive abduction/adduction and rotation allow the hand to adapt itself to grasp a variety of shapes.

When these joints are in a more flexed position, they become less flexible but also more stable, which is helpful for feats requiring strength or force.

The collateral ligaments expand like a fan toward the palmar ligament.
Interphalangeal joints

The articular surfaces of these joints can be compared to a convex double-track, which articulates with a concave double-track. They allow for anterior and posterior movements (in the sagittal plane).

The capsule and ligaments are arranged similarly to the metacarpophalangeal joints.

Flexion is possible between the proximal and middle phalanx...

...but extension is usually limited to 180°.

Between the middle and distal phalanx, flexion is possible; extension is also possible, but usually within a limited range.
Muscles of the wrist and hand with their many bony attachments

Muscles that directly move the wrist are shown in regular type. Muscles that move the fingers and indirectly the wrist are shown in italic.

**Humerus:**
- palmaris longus
- flexor carpi radialis
- flexor carpi ulnaris
- flexor digitorum superficialis
- extensor carpi radialis longus
- extensor carpi radialis brevis
- extensor digitorum
- extensor digitii minimi
- extensor carpi ulnaris

**Radius:**
- flexor digitorum superficialis
- flexor pollicis longus
- abductor pollicis longus

**Ulna:**
- flexor digitorum profundus
- flexor digitorum superficialis
- flexor pollicis longus
- flexor carpi ulnaris
- abductor pollicis longus
- extensor pollicis longus
- extensor pollicis brevis
- extensor indicis
- extensor carpi ulnaris

**Carpal and metacarpal joints:**
- palmaris longus
- flexor carpi radialis
- flexor carpi ulnaris
- extensor carpi radialis longus
- extensor carpi radialis brevis
- extensor carpi ulnaris
- abductor pollicis longus

**Phalanges:**
- flexor digitorum profundus
- flexor digitorum superficialis
- flexor pollicis longus
- extensor pollicis longus
- extensor pollicis brevis
- extensor digitorum
- extensor indicis
- extensor digitii minimi

In addition, there are muscles that only attach to the bones of the hand, the *intrinsic muscles of the hand*. The muscles that move the thumb and form the mound on the palm at the base of the thumb are called the *thenar eminence*. The muscles that move the little finger and form a fleshy eminence on the palm along the ulnar margin are called *hypotenar eminence*. There are also intrinsic muscles located between the metacarpals, called the *interosseous* and *lumbrical* muscles.
Flexors of the wrist

There are three flexor muscles located at the anterior surface of the forearm. They originate at the medial epicondyle of the humerus and insert into the wrist.

**Flexor carpi ulnaris**

runs from the common flexor origin at the medial epicondyle of the humerus and descends along the medial ulna and styloid process, inserting on the pisiform, and also the hamate.

*Actions*: flexes and adducts the wrist; plays a very minor role in assisting flexion of the elbow

*Innervation*: ulnar nerve (C7-C8)
**Palmaris longus**
arises from the common flexor origin at the medial epicondyle of the humerus and inserts on the flexor retinaculum and palmar aponeurosis.

*Actions:* flexes the wrist and assists weakly in elbow flexion
*Innervation:* median nerve (C7-C8)

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**Flexor carpi radialis**
arises from the common flexor origin at the medial epicondyle of the humerus and then runs down the forearm. Its tendon runs through the carpal tunnel and inserts on the bases of metacarpals II and III.

*Actions:* flexes and abducts the wrist, acting on both the radiocarpal and midcarpal joints; assists weakly in elbow flexion and pronation
*Innervation:* median nerve (C6-C7)
Extensors of the wrist

Radialis muscles

These two muscles pass lateral to the radius, through a fibrous sheath at the level of the wrist, and end on the posterior side of the hand.

**Extensor carpi radialis longus**
- originates from the lateral epicondyle (common extensor origin) and supracondylar ridge of the humerus.
- Its tendon passes under the extensor retinaculum and inserts on the posterior base of metacarpal II.

**Extensor carpi radialis brevis**
- arises from the common extensor origin and inserts on the posterior base of metacarpal III.

*Actions:* extends the wrist; participates in elbow flexion

*Innervation:* radial nerve (C6-C7)

*Actions:* extends the wrist, abducts the hand (radial deviation); participates in elbow flexion

*Innervation:* radial nerve (C7-C8)
Extensor carpi ulnaris
originates from the common extensor origin
and the posterior border of the ulna,
passes under the extensor retinaculum,
and inserts on the posterior base of metacarpal V.

*Actions:* extends
and adducts the wrist;
participates weakly
in elbow extension

*Innervation:*
radial nerve (C7-C8)
Extrinsic flexors of the fingers

These are two muscles whose mass is arranged on top of each other on the anterior surface of the forearm and whose tendons end on the phalanges.

**Flexor digitorum profundus**

has a broad origin on the anterior and medial ulna, and the medial half of the interosseous membrane which connects the ulna and radius.

It splits into four tendons which pass through the carpal tunnel and insert on the distal phalanges of fingers II through V.

At the level of the metacarpals, these tendons attach to the lumbrical muscles.

*Actions:* flexes the third phalanx toward the second and participates in flexion of the other two phalanges

*Innervation:* median and ulnar nerves (C7-T1)

Once at the level of the middle phalanx, a tendon passes through a notch formed when the tendon of the flexor digitorum superficialis splits in two.
**Flexor digitorum superficialis**

has two heads:
- one from the common flexor origin and the coronoid process of the ulna;
- the other from the anterior surface of the radius.

The muscle splits into four tendons which pass through the carpal tunnel (superficial to the tendons of flexor digitorum profundus, of course), split into “Y” shapes (to accommodate passage of other flexor tendons), and inserts bilaterally on the middle phalanges of fingers II through V.

**Actions:** flexes the second phalanx toward the first, and, due to the fibrous sheath, flexes the first phalanx on the metacarpals. It assists in flexion of the wrist, and plays a weak role in elbow flexion.

*Innervation:* median nerve (C7-T1)

Side view of a finger, showing the tendons of the flexor muscles

Action of flexor digitorum profundus

Action of flexor digitorum superficialis
Extrinsic extensors of the fingers

These three muscles are located on the posterior side of the forearm. Their tendons insert on the posterior side of the hand.

**Extensor digitorum**
- arises from the common extensor origin,
- passes down the back of the forearm,
- and splits into four tendons.

Each tendon in turn splits into three bands, of which the central band inserts on the posterior base of the proximal and middle phalanges...

...while the two lateral bands reunite at the base of the distal phalanx.

*Actions:* together with the lumbricals and interosseous muscles, it assists in extension of the interphalangeal joints

*Innervation:* radial nerve (C6-C8)
**Extensor indicis**

arises from the posterior ulna and interosseous membrane, below the origin of extensor pollicis longus. Its tendon joins that of extensor digitorum leading to the index finger.

*Action:* reinforces the action of extensor digitorum on the level of the index finger

*Innervation:* radial nerve (C6-C8)

**Extensor digiti minimi**

originates from the common extensor origin, and its tendon joins that of extensor digitorum leading to the little finger.

*Action:* reinforces the action of extensor digitorum on the level of the little finger

*Innervation:* radial nerve (C6-C8)
Intrinsic muscles that move the fingers

The intrinsic muscles of the hand are those that attach solely to the bones of the hand.

The **interossei**
are small muscles
originating from the metacarpals.
They occupy the spaces
between the metacarpals.

There are four dorsal interossei
originating close to the back of the hand...

...and three palmar
interossei originating
closer to the palm
of the hand.

Their major tendon
consists of two parts:
- one inserts on the base
  of the proximal phalanx (the lateral tubercle)
- another consists of three fibers:
  * the first skirts the phalanx and joins the identical fibers
    on the adjacent interosseous
  * the second and third insert on the edges of the extensor digitorum tendon
    at the level of the proximal and middle phalanges.
*Actions:* the dorsal interossei abduct and the palmar interossei adduct the fingers

*Innervation:* ulnar nerve (C8-T1)

Acting together bilaterally, the first part of the tendon and the first fiber of the second part flex the proximal phalanx. The two fibers that insert on the extensor tendon pull on the proximal phalanx and extend the middle phalanx toward the proximal, and the distal phalanx toward the middle.

The four *lumbricals* originate from the tendons of flexor digitorum profundus, and insert on the tendons of extensor digitorum.

*Actions:* collectively, the lumbricals flex the metacarpophalangeal joints and extend the interphalangeal joints

*Innervation:* ulnar nerve (C8-T1)
Intrinsic muscles of 5th finger

The bodies of the **hypotenar muscles** provide the bulk of the hypothenar eminence on the medial side of the palm.

**Opponens digiti minimi** originates from the flexor retinaculum and hamate hook, and inserts on the medial surface of metacarpal V.

*Action:* helps move the little finger toward the thumb (for grasping) and create the curvature of the palm

*Innervation:* ulnar nerve (C8-T1)

**Flexor digiti minimi**

has the same origin as opponens, and inserts on the base of the proximal phalanx of finger V.

*Action:* flexes the little finger

*Innervation:* ulnar nerve (C8-T1)

**Abductor digiti minimi**

arises from the pisiform and flexor retinaculum, and inserts in the same place as flexor digiti minimi.

*Actions:* abducts the little finger, and flexes its proximal phalanx

*Innervation:* ulnar nerve (C8-T1)
Carpometacarpal articulation of thumb

The inferior surface of the trapezius is:
- concave across
- convex from front to back.

The superior surface of metacarpal I, which articulates with it, is:
- concave from front to back
- convex across.

Together, the two structures form a saddle joint...

...which allows the thumb to move through the three planes of movement described on pages 8-10.

Thus, the thumb can be moved to oppose the other fingers, allowing grasping and manipulation of objects.

Additionally, the thumb has the same mobility in its metacarpophalangeal and interphalangeal joints as the other fingers.
Thumb

The thumb has a specific orientation vis-à-vis the rest of the hand:

- the scaphoid bone is positioned at a 40° angle anteriorly to the carpal plane
- the first metacarpal is positioned at a 20° angle to the second metacarpal and placed at a 40° angle anteriorly.

Thus, in a hand at rest, the thumb faces the other fingers at a right angle.

Movements of the thumb (i.e., metacarpal I) must be defined differently from those of the other fingers.

In extension, the metacarpal moves posterolaterally, while in flexion it moves anteromedially, closer to the palm.
In **abduction**, it moves anterolaterally, while in **adduction** it moves posteromedially.

The capsule of carpmetacarpal joint I is slack, allowing some axial rotation in addition to the movements described above, and further enhancing the thumb’s mobility.

**Thumb joints**

**Metacarpophalangeal joint I** differs from II through V in a few respects:

- It is more massive.
- The capsule is not as taut and allows some axial rotation.
- Two small sesamoid bones are embedded in the palmar fascia, and serve for tendon attachment.

The **interphalangeal joint** is similar to those of fingers II through V, except for being more massive.
Extrinsic muscles of the thumb

**Flexor pollicis longus**
originates from the anterior radius.
Its tendon passes through the carpal tunnel
and inserts on the base of the distal phalanx of the thumb.

*Action:* flexion of interphalangeal joint I,
metacarpophalangeal joint I,
and carpometacarpal joint I;
assists in flexion of the wrist and abduction
(radial deviation)

*Innervation:* anterior interosseous nerve (C7-C8)

**Abductor pollicis longus**
arises from the posterior surfaces
of the ulna, radius,
and interosseous ligament,
inferior to supinator.
The tendon passes
under the extensor retinaculum
and inserts on the lateral base
of metacarpal I.

*Action:* anteromedial movement
of the thumb; also
assists in flexion of the wrist
and abduction (radial deviation)

*Innervation:* radial nerve (C7-C8)
**Extensor pollicis brevis**

originates inferior to abductor pollicis longus.
The tendon inserts on the base of the proximal phalanx of the thumb.

*Actions:* extension of metacarpophalangeal and carpometacarpal joints of thumb; assists in abduction of thumb

*Innervation:* radial nerve (C7-T1)

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**Extensor pollicis longus**

arises on the posterior ulna and interosseous membrane, inferior to extensor pollicis brevis.
It inserts on the base of the distal phalanx of the thumb.

*Actions:* same as extensor pollicis brevis, but also extends the interphalangeal joint of the thumb (the only muscle that can do this)

*Innervation:* radial nerve (C7-C8)

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When the thumb is fully extended, a depression known as the “anatomical snuffbox” can be seen at the posterior base of the thumb.

It is bordered laterally by the tendons of abductor pollicis longus and extensor pollicis brevis, and medially by the tendon of extensor pollicis longus.
Intrinsic muscles of the thumb

Adductor pollicis has two fibers:
- Adductor pollicis obliquus arises from the trapezoid and capitate bones.
- Adductor pollicis transversus arises from the 2nd and 3rd metacarpals and the corresponding metacarpophalangeal joint.

The two fibers insert on the medial base of the proximal phalanx of the thumb, and the medial sesamoid bone located at metacarpophalangeal joint I.

*Actions:* moves the 2nd metacarpal toward the 1st; also flexes the metacarpophalangeal joint.

*Innervation:* ulnar nerve (C8-T1)

Flexor pollicis brevis consists of two layers:
- a deep layer, which arises from the trapezoid and capitate
- a superficial layer, which arises from the trapezium and the flexor retinaculum.

The two layers merge into one tendon, which inserts on the lateral base of the proximal phalanx of the thumb, and the lateral sesamoid bone located at metacarpophalangeal joint I.

*Actions:* moves the metacarpals anteromedially and in medial rotation, and flexes the proximal phalanx of the thumb.

*Innervation:* median and ulnar nerves (C8-T1)
**Opponens pollicis**
arises from the crest of the trapezium
and the flexor retinaculum
on the anterior medial surface of the first metacarpal.
It inserts on the lateral shaft of metacarpal I.

*Actions*: anteromedial movement
of the first metacarpal,
causing
a strong medial rotation;
important in grasping movements

*Innervation:*
median nerve (C6-C7)

**Abductor pollicis brevis**
arises from the flexor retinaculum, scaphoid, and trapezium,
and inserts on the lateral base
of the proximal phalanx of the thumb
next to flexor pollicis brevis.

*Actions:*
pulls the metacarpal anteriorly
and flexes
the metacarpophalangeal joint

*Innervation:*
median nerve (C8-T1)