The Region of the Wrist and Hand

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The lower extremity is ossified during the second year, but does not unite with the shaft before the twentieth year. The development of the ulna also is from three centres, one for the shaft and one for each end. At birth the extremities are entirely cartilaginous. The olecranon does not begin to ossify until the tenth year, and it is joined to the shaft about the sixteenth year. The lower extremity ossifies in the fourth year, and joins the shaft in the twentieth year. It should be noted that the epiphyses which meet at the elbow unite with their shafts earlier than those at the opposite ends of the bones, also that the foramina of the medullary arteries are directed toward the elbow.

In amputation through the middle of the forearm by the antero-posterior oval-flap method, the parts exposed in the flaps when made upon the left side bear the following relations (Plate 51, Fig. 3). The anterior flap is composed chiefly of the flexor muscles, in the margin of which in the superficial fascia is the cut superficial median vein (No. 1). The median nerve (No. 3) is in the middle of the flap, between the severed superficial and deep flexor muscles. The ulnar vessels and the ulnar nerve (No. 5) are close to the sawn end of the ulna, and the radial vessel and the radial nerve are close to the sawn end of the radius. The interosseous vessels and nerve are between the bones. The posterior flap is composed chiefly of the extensor muscles, and in its margin will be found the superficial radial vein (No. 10).

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The skeleton of the hand consists of the carpus, or wrist, which connects the hand with the forearm, the metacarpus, or median portion of the hand, and the phalanges, or digital extremities. The carpal bones are eight in number, polygonal in shape, and are composed of cancellous tissue enclosed in a compact layer. They are arranged in two rows, each of which contains four bones, counting from the external or radial side, as follows: in the upper or proximal row, the scaphoid, semilunar, cuneiform, and pisiform; in the lower or distal row, the trapezium, trapezoid, magnum, and unciform. Each of these little bones presents a dorsal surface which is usually comparatively smoother and larger than the
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The palmar surface, which is rough for the attachment of the ligaments, while the lateral borders are covered, in the recent state, with articular cartilage. When they are collectively united they form an arch with its concavity toward the palm, the scaphoid and the trapezium, the two outer bones of the two rows, and the pisiform and the unciform, the two inner bones of the two rows, projecting laterally. The contiguous surfaces of the carpal bones are so adapted that they form with one another gliding joints, the motion between any two of them being very slight, and limited to extension and flexion, with the exception of the os magnum, which appears to be also capable of a very little rotation. The articulation between the two rows, the intercarpal joint, however, admits of considerable motion, and materially contributes to the flexion and extension of the hand. The three principal bones of the upper row, the scaphoid, semilunar, and cuneiform, are connected by interosseous ligaments at their margins so that they present a convex surface which is received into the concavity formed by the articular surface of the lower end of the radius and the under surface of the triangular fibro-cartilage, thus establishing the important radio-carpal or wrist joint (Plate 52, Fig. 5).

The triangular fibro-cartilage separates the inferior radio-ulnar joint (page 375) from the wrist. It extends transversely beneath the lower end of the ulna, being attached by its apex to the groove between the styloid process and the head of the ulna, and by its base to the ridge between the ulnar depression and the articular surface of the lower extremity of the radius. Its lower surface is therefore really a continuation inward of the radial articular surface. The synovial membrane lining the cavity of the wrist-joint is separated from the synovial pouches between the carpal bones by the interposition of the interosseous ligaments, but there is very often a communication between the synovial cavities of the inferior radio-ulnar and radio-carpal joints through a deficiency in the triangular fibro-cartilage. The flexor and extensor tendons as they pass over this region afford strong protection to it, but beneath them there are fibrous bands which extend mostly from the margins of the radius and fibro-cartilage to the first row of carpal bones, and which with the intervening connective tissue constitute the capsular ligament of the wrist. The
various bands which have been specialized are the anterior ligament (or ligamentum arcuatum), composed mainly of intersecting fibres which pass obliquely from the anterior lip of the radius to the palmar surface of the scaphoid, semilunar, and cuneiform bones, a few fibres being inserted also into the os magnum. This is reinforced by an additional band placed more superficially, extending from the base of the styloid process of the ulna to the cuneiform bone, and attached to the fibro-cartilage between them; the external lateral ligament, which is short and thick and extends from the styloid process of the radius to the outer side of the scaphoid; the posterior ligament (or ligamentum rectum), consisting of intersecting fibres which pass from the posterior margin of the radius and the fibro-cartilage to the dorsal surface of the semilunar and cuneiform bones; and the internal lateral ligament, which is a round band, longer and narrower than the external, and extends from the tip of the styloid process of the ulna to the cuneiform bone.

The movements permitted at the wrist-joint are flexion, extension, abduction, adduction, and circumduction, but not rotation. This joint acts harmoniously with the intercarpal and carpo-metacarpal joints, all of them being closely associated, so that they move simultaneously. The radio-carpal joint is supplied by filaments from the ulnar and posterior interosseous nerves. In opening the wrist-joint from the dorsal surface, as in amputation (Plate 52, Fig. 4), the peculiar convex arrangement of the upper row of carpal bones and the cup-shaped concave surface formed by the lower end of the radius and triangular cartilage present themselves, together with several bands of the capsule which project across the cavity of the joint and about which the synovial membrane is gathered into folds.

The pisiform bone articulates with the cuneiform bone, and the joint thus formed is surrounded by a capsular ligament and provided with a distinct synovial membrane. It is also strongly connected by ligamentous fibres with the unciform and fifth metacarpal bones. It serves mainly to give attachment to the flexor carpi ulnaris and abductor minimi digitii muscles. Besides the synovial membranes peculiar to the inferior radio-ulnar joint, to the radio-carpal or wrist joint, and to the piso-cuneiform joint, just described, there are two distinct synovial membranes, enclosed
within the articulations formed by the carpal bones in relation to one another (the intercarpal joint) and to the bases of the metacarpal bones. The largest of these extends between both rows of the carpal bones, sending short pouches upward between the bones of the first row, and longer pouches downward between the bones of the second row, which are expanded between the latter and the bases of the contiguous metacarpal bones. The smaller synovial membrane is interposed between the trapezium and the metacarpal bone of the thumb. It is not uncommon to find that the interosseous ligament between the magnum and unciform bones is attached to the ridge on the fourth metacarpal bone, and consequently there is a subdivision of the larger synovial membrane between the unciform and the bases of the fourth and fifth metacarpal bones. The carpal bones are all connected by interosseous ligaments at their dorsal and palmar margins, of variable development, which blend with the especial ligaments of the intercarpal joint, and are called, from their positions, the palmar and dorsal ligaments. The palmar consists of strong fibres which radiate from the tuberosity of the os magnum to all the adjacent bones, and therefore is sometimes known as the ligamentum radiatum. The dorsal is somewhat weaker, and consists mostly of transverse fibres which extend from the back of the os magnum over the other bones and unite with the dorsal ligaments of the radio-carpal joint above and the carpo-metacarpal joints below.

The metacarpal bones, five in number, are modified long bones, each consisting of a somewhat triangular shaft, slightly bowed, with the concavity toward the palm. The proximal ends, or bases, are irregular, presenting tuberosities for the attachment of the ligaments and smooth facets for articulation with the carpal bones and the adjoining metacarpal bones, with which they are in relation. The distal ends, or heads, are quadrato, and provided with lateral depressions for ligaments, and spheroidal eminences for reception upon the glenoid surfaces of the proximal ends of the first phalanges. The articular processes of the heads embrace more of the palmar than of the dorsal surfaces. The metacarpal bones of the fingers are proportionately more slender than the metacarpal bone of the thumb, which is shorter and broader. They all diverge slightly
PLATE 53.

Figure 1.

Topographical survey of the right side of the head, face, and neck, with special adaptation to cranio-cerebral study; the localization of the areas of distribution of the sensory nerves, and spots where electrical stimulation produces reflex contractions of some of the muscles in these regions. Also the landmarks for the operations of tracheotomy and of laryngectomy.

1. Cutaneous area of supra-orbital nerve.
2. Position of superior frontal fissure.
3. Cutaneous area of auriculo-temporal nerve.
4. Position of the fissure of Rolando.
5. Position of horizontal branch of the fissure of Sylvius.
6. Spot where reflex contraction of the temporal muscle may be produced.
7. Cutaneous area of occipitalis major nerve.
8. Cutaneous area of occipitalis minor nerve.
9. Spot where reflex contraction of the splenius muscle may be produced.
10. Spot where reflex contraction of the trapezius muscle may be produced.
11. Posterior cervical folds of the integument produced by contraction of the trapezius muscle.
12. Spot indicating position of the brachial plexus of nerves.
13. Cutaneous area of supra-temporal nerve.
15. Cutaneous area of infra-temporal nerve.
16. Cutaneous area of occipitalis major nerve.
17. Position of second branch of the fissure of Sylvius.
18. Cutaneous area of infra-orbital nerve.
20. Cutaneous area of temporalis posterior branch of the superior maxillary nerve.
21. Spot where reflex contraction of the masseter muscle may be produced.
22. Cutaneous area of buccal nerve.
23. Cutaneous area of mental nerve.
24. Position where facial artery and vein pass over the body of the jaw in front of masseter muscle.
25. Spot where reflex contraction of the sternocleido-mastoid muscle may be produced.
26. Position of body of the hyoid bone.
27. Cutaneous area of auricularis magnus nerve.
28. Anterior prominence of the thyroid cartilage.
29. Point where the common carotid artery is in relation to the transverse process of the fourth cervical vertebra.
30. Position of the hoop of the cricoid cartilage.
31. Spot where reflex contraction of the omohyoid muscle may be produced.
32. Supra-ternal notch.

The left hand in the position of pronation, showing a topographical survey of the areas of distribution of the sensory nerves on the back of the hand and fingers, and spots where electrical stimulation produces reflex contraction of some of the muscles.

1. Area supplied by the median nerve on ulnar side of dorsal surface over third phalanx of middle finger.
2. Lowest distribution of ulnar nerve on ulnar side of middle finger.
3. Area supplied by median nerve on dorsal surface of radial side over third phalanx of ring finger.
4. Lowest distribution of ulnar nerve on ulnar side of dorsal surface of ring finger.
5. Ulnar nerve on radial side of little finger.
6. Ulnar nerve on ulnar side of little finger.
7. Spot where contraction of the third dorsal interosseous muscle may be produced.
8. Spot where contraction of the fourth dorsal interosseus muscle may be produced.
9. Spot where reflex contraction of the abductor minimi digitii muscle may be produced.
10. Ulnar nerve on back of wrist.
11. Median nerve on dorsal surface of third phalanx of middle finger.
12. Lowest distribution of radial nerve on radial side of middle finger.
15. Median nerve on radial side of dorsal surface of third phalanx of index finger.
16. Lowest distribution of radial nerve on radial side of index finger.
17. Radial nerve on radial side of dorsal surface of index finger.
18. Spot where contraction of second dorsal interosseus muscle may be produced.
19. Spot where contraction of first dorsal interosseus muscle may be produced.
20. Radial nerve on dorsal surface of wrist.

The right hand in the position of supination, showing a topographical survey of the areas of distribution of the sensory nerves on the palm of the hand and anterior surface of the fingers, and spots where some of the muscles may be caused to contract by electrical stimulation. Also the surface-markings on the palm of the hand in relation to the arterial arches.

1. Median nerve on ulnar side of palmar surface of middle finger.
2. Median nerve on radial side of palmar surface of ring finger.
3. Ulnar nerve on ulnar side of palmar surface of ring finger.
4. Ulnar nerve on palmar surface of radial side of little finger.
5. Ulnar nerve on palmar surface of ulnar side of little finger.
7. Spot where contraction of the third lumbrical muscle may be produced.
8. Spot where contraction of the fourth lumbrical muscle may be produced.
9. Linx hepatica.
10. Linx cephalica.
11. Spot where contraction of the opponens pollicis digiti minimi muscle may be produced.
12. Spot where contraction of the abductor pollicis longus muscle of the thumb may be produced.
13. Spot where contraction of the opponens pollicis digiti minimi muscle may be produced.
14. Spot where contraction of the palmaris brevis muscle may be produced.
15. Ulnar nerve on front of wrist.
16. Median nerve on palmar surface of radial side of middle finger.
17. Median nerve on palmar surface of ulnar side of index finger.
18. Median nerve on palmar surface of radial side of index finger.
19. Spot where contraction of the second lumbrical muscle may be produced.
20. Spot where contraction of first lumbrical muscle may be produced.
21. Spot where contraction of the adductor pollicis muscle may be produced.
22. Internal branch of median nerve on palmar surface of thumb.
23. External branch of median nerve on palmar surface of thumb.
24. Spot where contraction of the flexor brevis pollicis muscle may be produced.
25. Linx visus.
26. Spot where contraction of the abductor pollicis muscle may be produced.
27. Median nerve below the wrist.
28. Linx transversus carpi.
29. Median nerve above the wrist.
30. Spot where contraction of the flexor longus pollicis muscle may be produced.
31. Spot where contraction of the tendon of index and little fingers may be produced.
32. Spot where contraction of the tendons of middle and ring fingers may be produced.
from the carpus, but that of the thumb diverges more than the others. The metacarpal bone of the index finger is the longest of the series, the rest of which are successively shorter toward the little finger, its metacarpal bone being longer than that of the thumb. The latter is peculiar in having its palmar surface turned toward the ulnar side of the hand; its base has no lateral facet, being provided with an oval facet for articulation with the trapezium only. The head is less pronounced than in the corresponding bones, and has two marked processes on the palmar surface for the two sesamoid bones (page 402). The joint between the trapezium and the metacarpal bone of the thumb is distinct and protected by a capsular ligament, which is particularly strong in the external and dorsal portions. The proximal ends of the metacarpal bones are connected by interosseous ligaments, and each carpo-metacarpal joint is provided with palmar, dorsal, and lateral ligaments.

The phalanges are fourteen in number,—three in each finger and two in the thumb. They are designated as the first or proximal, the second or medial, and the third or distal. The latter are also called the ungual phalanges, because they support the nails. The phalanges in each of the digital extremities successively decrease in size toward the wrist. They are all long bones with semi-cylindrical shafts. The dorsal surfaces of the first and second phalanges are slightly convex, except that of the thumb, which is rather concave and tapers toward the distal end. The upper ends of the first phalanges are severally provided with glenoid depressions variably modified for articulation with the metacarpal bones to which they belong, and their lower ends present trochlear surfaces for articulation with their proper second phalanges. The upper ends of the latter have each a double concavity for the reception of the trochlear surfaces of the first phalanges, and their lower ends are also provided with similar trochlear surfaces, but smaller than those of the first phalanges. The second phalanges of the middle and ring fingers are about equal in length, that of the index finger is shorter, and that of the little finger is the smallest of the series.

The third or ungual phalanges are all provided with concavities at their upper ends, each presenting two depressions, for articulation with the
second phalanges, and they terminate in the horseshoe-shaped ungual processes, which are roughened on their palmar surfaces for the attachment of the pulps of the fingers. The ungual process of the thumb is the largest and broadest, while the ungual processes of the middle, ring, index, and little fingers follow in order as named.

The metacarpo-phalangeal joints are enarthrodial, being capable of extension, flexion, abduction, adduction, and slight rotation. The contiguous bony surfaces are each provided with a layer of articular cartilage and a synovial membrane, the glenoid depressions on the proximal ends of the first phalanges being deepened by small glenoid ligaments. These joints are surrounded by capsular ligaments, which being comparatively weak in their dorsal portions are strengthened by expansions from the extensor tendons (Plate 49). The fibres at each side are very strong, and have been specialized as lateral ligaments.

The second and third interphalangeal joints are ginglymoid, being capable only of flexion and extension. They are constructed similarly to the metacarpo-phalangeal joints, having glenoid and capsular ligaments, the side bands of the latter being strengthened into lateral ligaments. At the metacarpo-phalangeal joint of the thumb there are always found two sesamoid bones, the outer being the larger. They are the ossified nodules of fibro-cartilage, in relation to the lateral ligaments, and receive the insertions of short muscles.

The spaces between the metacarpal bones are occupied by the interosseous muscles, which are arranged in two sets, palmar and dorsal. There are three palmar interosseous muscles, each of which has a single origin. The first arises from the base and front of the metacarpal bone of the index finger, and is inserted into the ulnar side of the dorsal aponeurosis of the three phalanges belonging to the digital extremity of that finger. The second arises from the metacarpal bone of the ring finger, and is inserted into the radial side of the dorsal aponeurosis of the corresponding phalanges. The third arises from the metacarpal bone of the little finger, and is inserted into the radial side of its phalanges. There are four dorsal interosseous muscles, each of which has two origins. The first arises from the ulnar side of the upper portion of the metacarpal bone.
of the thumb and the whole of the adjacent side of the metacarpal bone of the index finger, and is inserted into the radial side of the base of the proximal phalanx and the dorsal aponeurosis over the medial and distal phalanges of that finger. The second arises from the adjacent sides of the metacarpal bones of the index and middle fingers, and is inserted into the radial side of the aponeurosis enveloping the phalanges of the middle finger (Plate 49, Fig. 1, No. 19). The third arises from the adjacent sides of the metacarpal bones of the middle and ring fingers, and is inserted into the ulnar side of the aponeurosis over the phalanges of the middle finger. The fourth arises from the adjacent sides of the metacarpal bones of the ring and little fingers, and is inserted into the ulnar side of the aponeurosis over the phalanges of the ring finger. The general function of the palmar set is to adduct the fingers toward the middle line of the middle finger, while that of the dorsal set is to abduct the fingers from that line.

The dorsal aponeurosis of the fingers, above mentioned, is formed by the expansion of the extensor tendons (Plate 49) after they have given off the flat bands to the sides of the metacarpo-phalangeal joints. It is continued down the fingers, being attached by a middle slip to the bases of the medial phalanges, and by lateral slips which intersect and are inserted into the bases of the ungual phalanges (page 402). On the sides of the proximal phalanges the aponeurosis receives the insertions of the interosseous muscles, described above, as well as those of the lumbricales muscles. The latter are four slender bundles of muscular fibres which arise from the deep flexor tendons in the palm of the hand. The first and second are attached to the radial sides of the tendons of the index and middle fingers, and are inserted into the radial sides of the digital aponeuroses below. The third and fourth arise from the contiguous surfaces of the adjacent tendons of the ring and little fingers, and are inserted into the radial sides of their digital aponeuroses. The first and second lumbricales are supplied by the median nerve, the third and fourth by the ulnar nerve. Their function is to flex the metacarpo-phalangeal joints, but they can also assist the action of the extensor tendons in maintaining the extension of the interphalangeal joints. It has already been stated
that all the flexor tendons become enclosed in aponeurotic sheaths opposite the palmar surface of the metacarpo-phalangeal joints, and that as they enter these sheaths the superficial tendons divide into lateral slips, which diverge about the middle of the proximal phalanges, to allow the deep flexor tendons to pass between them. The two lateral slips of the superficial tendons blend together behind the deep tendons, and then separate again, to be finally inserted into the sides of the medial phalanges, while the deep tendons are continued on, to be inserted into the bases of the ungual phalanges. In this connection it should be noted that the metacarpo-phalangeal joints are capable of being flexed so that the fingers may be brought into the hollow of the palm, thus forming the fist, while the heads of the metacarpal bones and the bases of the proximal phalanges are made prominent at the knuckles. The fingers can be extended only very little beyond the plane of the metacarpus, but they can be readily moved laterally. The interphalangeal joints can be flexed or extended so that the separate phalanges shall move in the same manner as the entire fingers, but they have no lateral movement.

The construction of the joint of the thumb, between its metacarpal bone and the trapezium, enables it to be opposed to all the fingers. The special flexor (page 383) and extensor (page 388) muscles of the thumb have already been described. Besides these there are the muscles which constitute the ball of the thumb.

The abductor pollicis muscle (Plate 48, Fig. 3, No. 3) arises from the anterior annular ligament and the tubercle of the trapezium, and is inserted into the outer side of the proximal phalanx of the thumb. This muscle is supplied by a branch of the median nerve, and often consists of two slips, between which passes the superficialis volæ artery (page 389). The action of this muscle is to draw the thumb away from the rest of the hand.

The opponens pollicis muscle (Plate 48, Fig. 4, No. 2) arises beneath the abductor, also from the annular ligament and the trapezium, and is inserted into the metacarpal bone of the thumb upon the whole length of its radial border. It is supplied by a branch of the median nerve. By its action the thumb is brought forcibly in apposition with all the fingers.

The flexor brevis pollicis muscle has a double origin, a superficial portion
arising from the trapezium and annular ligament, which is inserted into the outer sesamoid bone and the radial surface of the proximal phalanx of the thumb, and a deeper portion which arises from the bases of the metacarpal bones of the index and middle fingers and the fibrous arch between them and the trapezoid and magnum and is inserted into the inner sesamoid bone and the base of the proximal phalanx of the thumb. The superficial portion is supplied by the median nerve, the deep portion by the ulnar nerve. The tendon of the long flexor muscle passes between these two portions, to be inserted into the base of the ungual phalanx of the thumb (page 383). The function of the flexor brevis is to flex the proximal phalanx of the thumb upon the palm.

The adductor pollicis muscle (Plate 48, Fig. 4, No. 7) is triangular, and arises from the shaft of the metacarpal bone of the middle finger, its fibres blending with those of the deep portion of the flexor brevis, to be inserted into the inner sesamoid bone and the adjoining part of the proximal phalanx of the thumb. Sometimes two portions of this muscle are differentiated as the oblique and transverse adductors, but they are very imperfectly separable. The adductor pollicis is supplied by the ulnar nerve. Its action is to augment that of the flexor brevis, and to enable the tip of the thumb to be brought into contact with the tips of the fingers. The mobility of the thumb and the power which it possesses through its many muscles render it one of the distinguishing features of the human hand.

The muscles of the ball of the little finger resemble somewhat those of the thumb. The abductor minimi digiti muscle (Plate 48, Fig. 2, No. 13) arises from the pisiform bone and its capsular ligament and is inserted into the ulnar side of the base of the proximal phalanx of the little finger, blending with its dorsal aponeurosis. It sometimes receives an accessory slip from the tendon of the flexor carpi ulnaris. The flexor brevis minimi digiti muscle (Plate 48, Fig. 4, No. 17) is really a part of the abductor. It arises from the unciform process, and is inserted also into the base of the proximal phalanx of the little finger and into the adjacent aponeurotic arch over the deep flexor tendon. The action of the abductor muscle is to draw the little finger away from the rest of the hand, and it is
assisted in this effort by the flexor brevis. The *opponens minimi digiti muscle* arises beneath the flexor brevis from the unciform process and the under surface of the annular ligament, and is inserted on the ulnar side of the metacarpal bone of the little finger. The action of this muscle is to draw the metacarpal bone of the little finger upon the palm, so as to strengthen its power of grasping. All these muscles of the little finger are supplied with branches from the ulnar nerve.

The *surface-markings of the wrist and hand* are of considerable topographical importance. The positions of all the bony prominences in this region should be noticed, in extension and flexion, as well as in supination and pronation. The lower extremities of the radius and ulna can be readily defined, because they are to a great extent superficial. It has already been stated that the laxity of the capsular ligament about the inferior radio-ulnar joint permits of slight lateral motion between the bones of this articulation when the radius is rotated, and consequently it is the styloid process of the ulna which is felt in supination, and not the head of that bone. The styloid process of the radius is placed more anteriorly than the corresponding process of the ulna, and is also twelve millimetres, or half an inch, lower. Below and in front of the radial styloid process the tubercle of the scaphoid bone can be felt, and below and in front of the ulnar styloid process is the pisiform bone. A line drawn from one styloid process to the other will be found to pass downward and outward, and its extremities represent the lower limits of the radio-carpal joint, the line of the joint itself being in the form of an arc with the convexity upward (Plate 52, Fig. 4).

The *skin* over the wrist is quite loose, thin, and free from fat. In front of the wrist the skin is closely connected with the deep fascia, and is marked by *transverse lines*, of which the *lowest* is usually very distinct (Plate 53, Fig. 3, No. 28). It is about one and a half centimetres, or three-quarters of an inch, below the wrist-joint, and crosses the os magnum in the line of the metacarpal bone of the middle finger. This line also corresponds to the upper border of the anterior annular ligament (page 412). About the middle of the anterior surface of the wrist the tendon of the palmaris longus muscle is usually plainly seen, especially when
the wrist is flexed with the fingers extended. The flexor carpi radialis tendon is on its outer side. The median nerve as it descends from the forearm to enter the palm beneath the annular ligament is between these two tendons (Plate 48, Fig. 4, No. 1). The tendon of the flexor carpi ulnaris muscle can be easily distinguished as it passes to the pisiform bone on the inner side of the wrist, when that joint is slightly flexed and the little finger closed upon the palm. The tendons of the flexor sublimis digitorum muscle are in the depression between the tendons of the flexor carpi ulnaris and the palmaris longus. Within the superficial fascia on the palmar surface of the thumb and the front of the wrist the superficial veins can be seen through the thin skin passing upward from the palmar plexus to empty into the median and ulnar veins. On the radial border of the wrist the tendons of the extensor ossis metacarpi and primi internodii pollicis muscles are brought into distinct relief when the thumb is abducted; and on the back of the wrist the tendon of the extensor secundi internodii pollicis muscle is rendered prominent when the thumb is forcibly extended and abducted. The extensor carpi ulnaris tendon can be felt upon the inner side of the posterior surface of the wrist, and to the radial side of it are the tendons of the extensor communis digitorum.

If the skin is removed from the back of the hand, the above tendons will be seen as they pass beneath the posterior annular ligament (Plate 49, Fig. 3, No. 7). This consists of a special condensation of the deep fascia in this locality, which is formed by the transverse fibres of the deep fascia prolonged from the forearm and augmented by special fibres which are attached to the ridges on the back of the lower end of the radius and thence pass obliquely inward over the capsular ligament of the inferior radio-ulnar joint to the ulnar side of the carpus, where they are attached to the pisiform and cuneiform bones. The several attachments of the deep fibres to the ridges on the radius convert the grooves into canals for the passage of the extensor tendons. There are six compartments thus formed in the posterior annular ligament, as follows: one for the extensor ossis metacarpi and the extensor primi internodii pollicis; one for the extensor radialis longior and the extensor radialis brevior; one for the extensor secundi internodii pollicis; one for the extensor indicis and the extensor
communis digitorum; one for the extensor minimi digiti; and one for the extensor carpi ulnaris. All these compartments are lined by synovial membranes which envelop the tendons and accompany them nearly as far as their insertions. Sometimes there is a communication between one of the above synovial sheaths and the cavity of the wrist-joint.

The skin over the back of the hand is very fine, and but loosely attached to the annular ligament enclosing the tendons and to the deep fascia prolonged from it to the knuckles below, owing to the extreme laxity of the subcutaneous tissue. This is manifest in oedema and extravasations which often occur here. The skin is also provided with numerous short fine hairs and sebaceous follicles. The hairs are so set that they have an inclination toward the ulnar border, and they are extended also over the dorsal surfaces of the first and second phalanges of all the fingers. The sweat-glands are not so numerous on the back of the hand as they are on the palm, where they are remarkable for the profuseness of their perspiration under certain conditions. The skin of the back of the hand is not very sensitive to tactile impressions.

The superficial veins of the hand (Plate 47, Fig. 3) arise mainly from the dorsal plexuses, which commence by radicles forming arches over the backs of the proximal phalanges. On the ulnar side the ulnar dorsal plexus is formed by the union of the vein from the little finger (the vena salvatella) with the veins from the third and fourth interdigital clefts. From this plexus usually two veins ascend to the forearm, a small anterior superficial ulnar and a larger posterior superficial ulnar. On the radial side the radial dorsal plexus is formed by the junction of the vein from the thumb (the vena cephalica pollicis) with veins from the index and middle fingers, which terminate in the radial veins above. There is much diversity in the arrangement of these veins on the back of the hand, and the two plexuses are frequently connected by a transverse venous link, which presents an H-shaped appearance.

As the vein from the thumb passes upward it crosses the hollow formed by the extensor tendons of the thumb, and in close relation with it are the branches of the radial nerve (Plate 47, Fig. 3, No. 9) which pass to supply the dorsal surface of the thumb and the dorsal surface of the index and
the radial side of the middle finger as far as their distal phalanges (Plate 53, Fig. 2). At the bottom of the hollow, beneath the tendons, the radial artery, in a bed of fat which separates it from the scaphoid and trapezium, passes (Plate 49, Fig. 1, No. 17) to the interval between the first and second metacarpal bones to enter the palm between the two portions of the abductor indicis muscle and form the deep palmar arch (page 415). Before leaving the back of the hand the radial artery gives off the posterior carpal artery, which passes beneath the extensor tendons, forming an arch with the corresponding branch from the ulnar artery. From this dorsal arch the dorsal interosseous arteries arise (Plate 47, Fig. 3, and Plate 49, Fig. 3). They descend to the muscles occupying the several interosseous spaces, supplying them and the other adjacent parts, and inosculating near the metacarpo-phalangeal joints with the perforating branches from the deep palmar arch. On the ulnar side of the back of the hand the ulnar nerve appears just below the styloid process of the ulna, and in relation to the vein from the little finger (Plate 47, Fig. 3, No. 5) it divides into branches which supply the dorsal surface of the little finger, the whole of the dorsal surface of the ring finger, except the radial border of the distal phalanx, and the dorsal surface of the ulnar side of the middle finger, except over the distal phalanx (Plate 53, Fig. 2, No. 10).

The palm of the hand presents some conspicuous features which should be closely examined. There is a large prominence on the radial side, formed by the muscles of the ball of the thumb, already described (page 404), which is called the thenar eminence; while upon the ulnar side the long prominence corresponding to the muscles of the ball of the little finger is the hypothenar eminence. The two eminences are sometimes named the heel of the hand. Between them, over the annular ligament, there is a depression, which broadens toward the fingers, and when the latter are flexed forms the hollow of the hand. The skin of the palm is attached to the fascia beneath along the many lines of flexion, three of which are especially marked and have been designated as follows. The first line, curving round the base of the thenar eminence, is caused by the constant flexion of the thumb, and is called the linea vitalis (Plate 53,
Fig. 3, No. 25). It corresponds to the attachment of the radial margin of the palmar fascia. The second line commences at the radial side of the hand, between the index finger and the thumb, and extends across the palm to about the middle of the metacarpal bone of the little finger, is caused by the apposition of the middle and index fingers with the thumb, and is known as the *linea cephalica*. This line indicates the position of the metacarpo-phalangeal joint of the index finger, and is a useful guide in its amputation. The third line, which is the lowest upon the extended palm, commences at the elevation between the index and middle fingers and runs obliquely to the ulnar border of the hand, is caused by the flexion of the middle, ring, and little fingers, and is known as the *linea mensalis*. The last two lines are intersected by another, less conspicuous, which takes a vertical course nearly over the metacarpal bone of the middle finger, is called the *linea hepatica*, and gives to these markings the characteristic outline of the letter M (Plate 53, Fig. 3). The second line where it crosses the metacarpal bone of the ring finger is about over the lowest part of the superficial palmar arch (page 414). The third line is the most important. It is one centimetre, or a little less than half an inch, above the metacarpo-phalangeal joints of the fingers which produce it, and indicates very nearly the upper limits of the synovial sheaths of the index, middle, and ring fingers. Just beyond this line the palmar fascia divides into its four slips (page 412). The position of the metacarpo-phalangeal joints can be ascertained by alternate flexion and extension, and will be found to be for each finger at a point midway between the third palmar line and the webs of the fingers. The same points refer to the bifurcation of the digital arteries (Plate 48, Fig. 4). When the proximal phalanges are extended and the medial and distal are flexed, three little elevations are noticed, formed by the pressing forward of the little cushions of fatty tissue which occupy the arches made by the digital slips of the palmar fascia over the flexor tendons. The palmar surface is further marked at the bases of the fingers by transverse flexion-folds, which are single for the index and little fingers and double for the middle and ring fingers. These folds are about two centimetres, or three-quarters of an inch, below the corresponding metacarpo-phalangeal joints. There
are similar folds produced by the flexion of the interphalangeal joints, the first of which is double and the second usually single for each finger. They do not correspond to the joints, being usually from three to one and a half millimetres, or from one-eighth to one-sixteenth of an inch, above them. The thumb is provided with two folds corresponding to its two joints, the upper one of which passes obliquely over the metacarpophalangeal joint. The free margin of the web between the fingers is called the plica interdigitalis, and is about two centimetres, or three-quarters of an inch, from the metacarpophalangeal joints on the palmar surface. These measurements are exact, but it is always best for practical purposes to remember the unfailing rule of exercising the functions of these joints when in doubt, which will demonstrate their position and features better than any description. The palmar epidermis varies in thickness mainly according to the uses to which the hands are put. There are abundant sweat-glands, as already stated. The papillae are exceedingly large and numerous, and contain touch-corpuscles. On the rounded pulps of the fingers they are arranged in irregular concentric ridges, never being precisely alike in any two hands.

The subcutaneous tissue of the palm is scanty, and resembles the same tissue in the scalp, as mentioned in the description of that structure, as it is intimately associated with the palmar fascia beneath. Owing to the denseness of this tissue and the thickness of the cuticle, the hand is peculiarly adapted to sustain the effects of pressure and friction. The ulnar border of the palmar part of the hand is remarkably well provided in this respect and protected by the soft parts, without the presence of any large nerves. The palmaris brevis muscle consists of short transverse fibres arising from the skin over the hypothenar eminence and attached to the palmar fascia. Its contraction assists in grasping. When the skin of the palm with the above muscle is carefully removed, the palmar fascia and the anterior annular ligament are exposed.

The palmar fascia is a strong, silvery-white, glistening tissue spread over the centre of the palm, and when completely developed is really the expansion of the tendon of the palmaris longus muscle (Plate 48, Fig. 1, No. 8). In such cases it overlies the annular ligament proper; but very
often it appears to be simply a downward prolongation from that ligament over the palm, the tendon of the palmaris longus losing itself in the upper margin of the ligament. The palmar fascia consists chiefly of strong longitudinal fibres, which constitute the outer or superficial layer, and can be separated by careful dissection (Plate 48, Fig. 2, No. 8) from a deep layer of transverse fibres which are in immediate relation with the lower border of the annular ligament. At the borders of the thenar and hypothenar eminences the palmar fascia becomes thinner, and a layer composed of the deeper transverse fibres passes over the muscles forming these eminences to blend with the dorsal fascia. Toward the fingers the fascia divides into four slips, which are inserted chiefly into the bases of the proximal phalanges and the anterior surfaces of the capsular ligaments of the metacarpo-phalangeal joints, while some of the deeper fibres form lateral slips which blend with the aponeurotic sheaths of the flexor tendons, and others pass round and join the dorsal aponeurosis over the extensor tendons. In the arches formed by the attachment of the slips there are little cushions of fatty tissue which enclose the digital nerves and arteries and the tendons of the lumbricales muscles as they pass to the fingers. Many of the fibres of the superficial layer of the fascia are associated with the skin, which renders its dissection from the fascia very tedious. From the deeper layer there are two weak slips which pass across to be attached to the lateral expansions enclosing the muscles of the thenar and hypothenar eminences. The one to the thumb is especially noticeable (Plate 48, Fig. 1, No. 4). From the under surface septa also pass to the metacarpal bones. Beneath the skin of the webs of the fingers there are transverse fibres, called the superficial transverse ligaments, which cross over the vessels and nerves and afford them greater protection from pressure when the hand is used in grasping. The palmar fascia, like all the expansions of the deep fascia, is subject to great variability, depending upon development. In the hands of mechanics it is always very strong, and among persons who habitually use their fingers requiring effort doubtless many accessory slips are produced. The ulnar artery and ulnar nerve descend to the palm over the annular ligament and between the two layers of the palmar fascia (Plate 48, Fig. 2, Nos. 11 and 12).
The anterior annular ligament consists of a strong transverse band of fibrous tissue arching across from the unciform process and the pisiform bone to the trapezium and the tuberosity of the scaphoid bone. It is continuous with the deep fascia of the forearm above and with the deep layer of the palmar fascia below. Most of the muscles of the ball of the thumb and of the little finger arise from it (page 404), and it holds in place the flexor tendons of the fingers and thumb and the median nerve (Plate 48, Figs. 2, 3, and 4). The anterior annular ligament is one of the most unyielding fibrous structures in the body. There are two synovial sacs placed beneath this ligament: one, the larger, lines the canal formed by the ligament arching across the carpus, and is reflected over the flexor tendons of the fingers so as to form a loose pouch four centimetres, or one and a half inches, above the ligament, while below it sends prolongations along the several tendons, forming sheaths for them as far as the middle of their corresponding metacarpal bones, except the little finger, which usually is accompanied by an extension as far as the attachment of the flexor profundus tendon at the base of the ungual phalanx. The smaller synovial sac is in relation to the flexor longus pollicis tendon, and extends above the annular ligament not quite so far as the other sac. It accompanies the tendon as far as its insertion into the ungual phalanx of the thumb. The tendons of the index, middle, and ring fingers are provided with separate synovial sheaths, which rarely communicate with the other synovial sacs, they being about two centimetres, or three-quarters of an inch, apart. The highest points of the digital sheaths usually correspond to the third flexion-line on the palmar surface, while they terminate at the bases of the ungual phalanges, so that the finger-pulps rest upon the periosteum, a fact which is often demonstrated in felon, or whitlow, by the rapid necrosis affecting the bones. This arrangement explains the fact that an abscess involving the thumb or the little finger is apt to spread to the forearm, while such an extension of suppuration does not often follow a similar affection of any of the other fingers.

The ulnar artery descends from the forearm in close relation to the pisiform and unciform bones, with the ulnar nerve close to its inner side. At the wrist both artery and nerve are embedded in adipose tissue and
THE REGION OF THE WRIST AND THE HAND.

protected by an expansion from the tendon of the flexor carpi ulnaris to the palmaris longus. Just after leaving the pisiform bone the *ulnaris profunda* is given off, and, accompanied by the deep branch of the ulnar nerve, passes between the abductor minimi digiti and flexor brevis minimi digiti muscles, while the main vessel continues between the two layers of the palmar fascia along the muscles of the ball of the little finger, two centimetres, or three-quarters of an inch, from and parallel with the linea vitalis on the surface. About midway between the latter and the linea cephalica the ulnar artery turns outward toward the web of the thumb, and, crossing over the branches of the median nerve and flexor tendons, anastomoses either with the radialis indicis or with the superficialis volæ artery, and sometimes with both, thus forming the *superficial arterial palmar arch* (Plate 48, Figs. 3 and 4). This arch is about six centimetres, or not quite two and a half inches, above the interdigital clefts. From the upper border or concavity of the arch several small recurrent branches arise which supply the carpal bursa and palmar fascia and inosculate with the carpal branches of the radial artery. From the lower border or convexity of the arch arise *four digital arteries*, which supply the fingers, except the radial side of the index and the thumb. The *first* descends over the muscles on the inner border of the palm to the ulnar side of the little finger, along which it runs to the tip. The *second, third, and fourth* descend vertically between the flexor tendons and on a line with the clefts between the fingers. About one and a half centimetres, or half an inch, above the clefts each artery, after receiving a communicating branch from the deep arch, bifurcates into two branches, which proceed along the opposed sides of the fingers as far as their tips. The lateral digital arteries in their courses freely communicate by transverse branches at the several joints, which they supply, as well as the sheaths of the tendons on both the palmar and dorsal surfaces. At the ungual phalanges the digital arteries subdivide into *palmar* and *dorsal* branches, which form plexuses in relation to the pulps of the fingers and the matrices of the nails respectively.

The *radial artery* enters the palm from the dorsal surface between the inner head of the flexor brevis and the adductor pollicis muscle (page 405),
and, after giving off the *arteria princeps pollicis* and the *radialis indicis*, continues inward as the *palmaris profunda*, under the branches of the median nerve and the flexor tendons, to anastomose with the *ulnaris profunda* and thus form the **deep arterial palmar arch** (Plate 48, Fig. 4). This arch is seven centimetres, or two and three-quarter inches, above the interdigital clefts. The *arteria princeps pollicis* at its origin is of large size, and passes between the abductor indicis (or first dorsal interosseous) and the adductor pollicis to the ulnar side of the palmar surface of the metacarpal bone of the thumb. In the interval between the lower portions of the flexor brevis muscle it divides into two lateral branches, which run along one or each side of the thumb and inosculate with each other similarly to the other digital arteries. The *radialis indicis artery* descends from its origin to the radial side of the index finger. Usually at the lower border of the adductor pollicis muscle this vessel communicates with the superficial palmar arch, and it often receives a branch from the princeps pollicis (Plate 48, Figs. 3 and 4). The deep arch receives three *perforating branches* from the dorsal carpal rete through the spaces between the metacarpal bones, and from its upper border gives off branches to the adjacent muscles and branches to the anterior carpal rete. From its lower border four small branches descend in relation to the palmar interosseous muscles and communicate with the digital arteries from the superficial arch, as above described. Occasionally one or more of these *interosseous branches* are substituted for the regular arteries to the fingers.

**Wounds of the palm** involving any of the principal arteries are always serious, in consequence of the free anastomoses between the vessels forming the arches, and of the difficulty of reaching the bleeding vessel and securing it in the wound without damaging other important structures. Nevertheless, the above procedure is the only proper one, as the hemorrhage can rarely be checked by tying either one or both of the main arteries above the wrist.

The *ulnar nerve*, after passing over the anterior annular ligament at the wrist, on the inner side of the ulnar artery, divides into a deep and a superficial palmar branch. The **deep palmar branch** supplies the muscles forming the hypothenar eminence, and accompanies the *ulnaris profunda*
artery to supply all the interosseous muscles, the two ulnar lumbricales, the adductor pollicis, the inner head of the flexor brevis pollicis, and the carpo-metacarpal and metacarpo-phalangeal articulations. The superficial palmar branch distributes filaments to the skin over the hypothenar eminence and the inner surface of the palm of the hand, and to the palmaris brevis muscle, and divides into two digital nerves, one to the ulnar side of the little finger and the other subdividing and supplying the opposed sides of the ring and little fingers (Plate 48, Fig. 4, and Plate 53, Fig. 3). The superficial branch of the ulnar communicates with the median nerve by a branch which passes beneath the superficial palmar arch.

The median nerve (Plate 48, Figs. 3 and 4), as it descends from the forearm under the anterior annular ligament, is enveloped in a fold of the synovial membrane. It is superficial to the flexor tendons, and as it enters the palm becomes somewhat swollen, of a pinkish color, and flattened, and divides into two branches of nearly equal size. The external palmar branch supplies recurrent filaments to the muscles of the ball of the thumb (the abductor pollicis, the opponens pollicis, and the outer head of the flexor brevis pollicis), and ends in three digital nerves, two to the thumb and one to the radial side of the index finger. The nerves to the thumb pass one on each side of the long flexor tendon as far as the ungual phalanx, where the outermost nerve connects with the terminal branch from the radial nerve. The nerve to the radial side of the index finger sends a filament to the first radial lumbrical muscle, and is continued to the ungual phalanx. The internal palmar branch of the median nerve divides into two digital branches, which pass vertically in a line with the clefts between the index and middle and the middle and ring fingers. About three centimetres, or one inch and a quarter, above the webs of the fingers the digital branches subdivide into lateral digital nerves, which are distributed as follows. The nerves from the first branch pass to the opposed sides of the index and middle fingers. The first digital branch also supplies the second radial lumbrical muscle. The nerves from the second branch pass to the opposed sides of the middle and ring fingers, receiving communicating branches from the ulnar nerve.

After many careful dissections, and repeated critical examinations on
the living regarding the cutaneous distribution of the various digital nerves, the author is inclined to believe that the arrangement as shown (Plate 53, Figs. 2 and 3) may be considered to represent their usual relations. It should be remembered that there is commingling of the fibres of the median and ulnar nerves by direct intercommunicating nerves both above and below the wrist, which probably accounts for the discrepancy in the observations on this subject. The extremities of the digital nerves are provided with peculiar little bodies, the Pacinian corpuscles, which are found in greater number on the nerves of the thumb and the index finger. Their function is unknown. The cutaneous nerve-supply of the hand is remarkable for the high development and the great number of the tactile corpuscles, which give to it an extraordinarily acute degree of tactile sensibility. The most sensitive area is the palmar surface of the tips of the fingers, and especially that of the ungual phalanx of the index finger. The dorsal surface of the hand is the least sensitive, as already stated.

The superficial lymphatic vessels commence by palmar and dorsal vessels on each finger, which unite and form plexuses on the palmar and dorsal surfaces of the hand respectively. Those of the palmar plexus are small and very close, and are arranged in an arch, from which vessels pass up the forearm accompanying the superficial veins. Those of the dorsal plexus are comparatively larger and more numerous, and their vessels wind round the borders of the forearm above the wrist and join with the vessels from the palmar plexus. The deep lymphatic vessels accompany the vena comites of the radial and ulnar arteries.

The nails are the horny plates which surmount the finger-tips upon their dorsal surfaces, and may be regarded as modified appendages of the epidermis. Each nail rests upon the extremely vascular and sensitive nail-bed of the dermis, the upper portion of which is called the matrix, whose papillae are arranged in ridges and protected by a fold of the skin. The part of the nail in relation to the matrix is the root. It is the thinnest part, and appears white and opaque just in front of the fold of the skin, and, owing to its crescent shape, is called the lunula. The latter is always more pronounced in the thumb than in the fingers. The growth of the nails is like that of the epidermis, but is more rapid in motion and
nail-cells in the nail-bed, so that as long as the matrix is preserved the nail is capable of reproduction. The nails vary in individuals, and under certain constitutional conditions are probably influenced by impeded circulation, for there appears to be a direct communication between the arteries and the veins in the matrix. It is noteworthy that during convalescence from many of the exanthematous diseases grooves make their appearance across the nails, presenting indications of growth. As the digital nerves supply large terminal filaments to the nail-beds, it is not difficult to account for the intense pain which is experienced when a splinter or other foreign body is thrust beneath the nails.

The development of the bones of the wrist and hand occurs at varying periods. At birth the carpal bones are all cartilaginous. The os magnum becomes ossified in the first year, the unciform in the second, the cuneiform in the third, the trapezium in the fourth, the semilunar in the fifth, the scaphoid in the sixth, the trapezoid in the seventh, and the pisiform not generally before the twelfth.

The metacarpal bones and the phalanges are usually composed of a shaft and an upper epiphysis. The shafts become ossified soon after birth, and the epiphyses are all united about the twentieth year.