practically that of Nicoladoni, the transplantation of the two peronei muscles into the tendo Achillis; or, as modified by Goldthwait, the tendon of the peroneus longus was inserted into the tendo Achillis and the brevis was transplanted into that of the flexor longus pollicis. If the tibialis posticus is paralyzed with resulting valgus, the peroneus brevis may be carried beneath the tendo Achillis and attached to its distal extremity.

The operation of tendon transplantation should not be performed until the recovery from the paralysis is considered impossible. The incision should be sufficiently long to expose the tendon and the muscular substance. The paralyzed muscle is quite different in color from the normal, being dull reddish-yellow, and the tendon is usually dull white in place of the silvery glistening color of the normal tendon. The splitting of the tendon should be begun high up, including, in some instances, muscle substance, and in joining the splices as much surface as possible of each splice should be apposed because the tendons do not readily unite. In certain instances it may be advisable to attach the transplanted tendon directly to the periosteum at the point at which its force may be exerted to best advantage. This as a routine measure is advocated by Lange (*Münch. med. Wochen.*, November 15th, 1900).

Fine silk is usually employed for suturing. The tendon sheaths are, as far as possible, closed by fine catgut and the skin incision by the same material. Before the operation is performed, all resistance to normal motion should be overcome by force, and by division of the contracted parts, if necessary. The attachment of the muscles or tendons should be made while the foot is held in proper position, and in many instances it is well to cut and overlap the paralyzed tendons to aid in retaining the foot in the improved attitude.

After the operation is completed, the foot should be fixed in a plaster bandage in the over-corrected position for several weeks or months. As a rule the foot should be supported by a brace until it is evident that the union of the parts is firm, and a good functional result is assured.

The prognosis will depend entirely upon the character of the paralysis. If the tibialis anticus is alone affected, it may be hoped that sufficient power may be borrowed from the other muscles to lift the foot at least enough to prevent awkwardness of gait, and to restrain deformity. Even more favorable is the prospect for the relief of varus caused by weakness of the abductors; but it is impossible for weak muscles like the peronei to supply the place of the great calf muscle. The power obtained from the peronei, however, which has become useless and even harmful because it draws the foot into deformity, may be sufficient to hold the heel in proper position and at least to aid the brace in retaining the foot in a normal attitude.

The relative strength of the muscles should be considered in selecting grafts, as well as in making a prognosis. According to Fick it is as follows, in kilogrameters:

BACK OF THE LEG.

The calf muscle—gastrocnemius and soleus	8.21
Tibialis posticus	.40
Peroneus longus	.44
Flexor com. digitorum	.37
Flexor longus pollicis	.82
Total	10.24

FRONT OF THE LEG.

Tibialis anticus	1.61
Extensor proprius pollicis	.39
Extensor longus digitorum	.72
Peroneus brevis	.31
Peroneus tertius	.20
Total	3.23

The importance of the calf muscle on the back, and of the tibialis anticus on the front of the leg, is apparent. The former is nearly four times as strong as the other muscles of the combined posterior group, the latter being nearly equal to all the others on the front of the leg. (Rudolph Fick, "Ueber die Arbeitsleistung der auf die Fussgelenke wirkenden Muskeln," Leipsic, 1892.)

It has been claimed that the transplanted muscle may become hypertrophied sufficiently to carry out its new function, but this is somewhat doubtful. Direct transplantation of muscles on the same principle as tendon grafting has also been performed by Drobnik, Goldthwait, and others; for example, the sartorius, the gracilis, or the tensor vaginæ femoris may be transplanted into the substance of the quadriceps extensor muscle. Drobnik has suggested the possibility of regenerating the paralyzed muscle by thus engrafting a portion of one that is still active, but this is, of course, a possible rather than a probable outcome.

The principle of the operation applies, of course, to other parts of the body as well, but the opportunities for its application are far less frequent than in the lower extremities.

TENDON SPLICING.—Division and overlapping of the tendons of paralyzed muscles may be employed with advantage in certain instances. For example, in complete paralysis of all the dorsal flexors of the foot, each tendon may be shortened and attached to the anterior ligament thus the toe-drop may be remedied or reduced to such an extent that the deformity may interfere but slightly with locomotion. In most instances, however, unless support is used the shortened part will relax subsequently.

ARTHRODESIS.—Arthrodesis, for the purpose of producing ankylosis of a joint, was first performed by Albert of Vienna, in 1878. Its field is practically limited to those cases in which no muscular power remains, the so-called dangle foot. It may be of service also in cases of partial paralysis, as in equinus or calcaneus, when the patient is unable to provide himself with apparatus.

The operation consists in opening the joint and removing the cartilage from the opposing surfaces of the bones, then sewing or nailing them to one another, or simply fixing the parts in a plaster bandage until union has taken place. If the case is one of simple calcaneus or equinus, without lateral deviation, the operation may be limited to the ankle joint, which may be opened from the back or front or side, as seems preferable. The cartilage is usually removed with a sharp spoon and at the same time relaxed tissue may be shortened after the Willett method, if the deformity be calcaneus; or the tendons on the front of the foot may be similarly shortened with the aim of lifting the toes to the proper level, if they are depressed. The operation, to be effective in cases of complete paralysis and dangle foot, must include all the larger joints of the foot. Even when ankylosis has been attained, there is a marked tendency to subsequent deformity. In cases of calcaneus, the removal of the astragalus in the manner described is the preferable operation.

Arthrodesis is also performed at the knee and at other joints for the purpose of fixing the part in a useful attitude. In certain instances the operation is indicated. It is, of course, limited to cases of hopeless paralysis and is more suitable to the older than to the younger class of patients.

The improvement in the gait obtained by the removal of deformity and fixation of the foot is often very marked, and support may often be discarded, but in early childhood, at least, cases should if possible be kept under observation in order that support may be applied if the deformity shows a tendency to recur.

Royal Whitman.

FOREARM, THE.—The forearm is that portion of the pectoral girdle or upper extremity lying between the elbow and wrist joints. Its bony framework comprises two bones, the radius and the ulna.

The *skin* of the forearm is soft and is usually well supplied with hairs, especially along the postero-external surface. Along the anterior surface the hairs are fewer and finer. The skin is freely movable throughout the forearm upon the deep fascial sheath. The bursa over the olecranon gives it free mobility at that point. Lying

within the layers of the superficial fascia are the superficial veins and the cutaneous nerves.

The SUPERFICIAL VEINS rise in two plexuses: the large *plexus of the dorsum of the hand* which is derived from the digital veins, and the smaller *plexus of the front of the wrist*, from the palm and thumb. These veins are larger than those of the deep set, have fewer valves and return most of the blood. At points of communication between these sets of veins, valves are regularly found.

The veins arising from these two plexuses are irregular in their distribution and are seldom symmetrical upon the two sides in the same body. For convenience four principal vein trunks are distinguished upon the outer, anterior and inner surfaces of the forearm: the *radial*, the *median*, the *anterior* and the *posterior ulnar* veins respectively. The *median* vein as it reaches a point opposite the insertion of the biceps receives a communication from the deep set which perforates the deep fascia. This trunk is short and is known as the *profunda*. The median at once divides into branches that diverge in V-form, the median-cephalic to the outer side and the median-basilic to the inner side of the biceps. The *median-cephalic* ascends to a point a little above the elbow, is joined by the *radial* vein, and this trunk, called the *cephalic*, lies in the furrow to the outer side of the biceps in the arm. The median cephalic vein overlies the cutaneous branches of the musculo-cutaneous nerve as they pass the elbow. The *median-basilic* vein passes upward and inward and is usually joined at a point about in front of the internal condyle by both the *ulnar* veins. The trunk so formed is called the *basilic* and lies to the inner side of the biceps in the arm. The median basilic is usually larger and shorter than the median cephalic; the basilic is usually a considerably larger trunk than the cephalic. The median basilic vein overlies from without inward the bicipital fascial aponeurosis, the brachial artery, a part of the anterior division and the whole of the posterior division of the terminals of the internal cutaneous nerve.

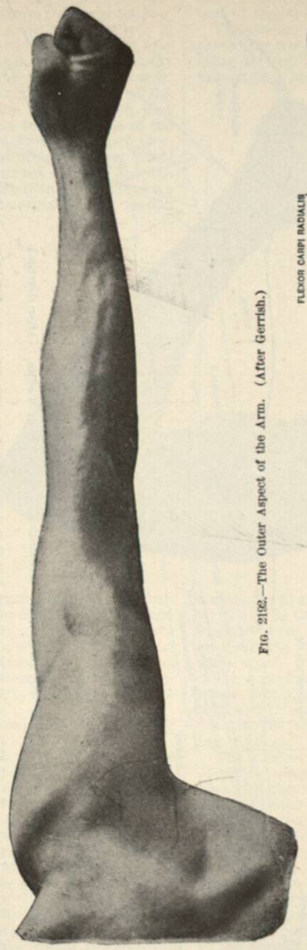

FIG. 2192.—The Outer Aspect of the Arm. (After Gerrish.)

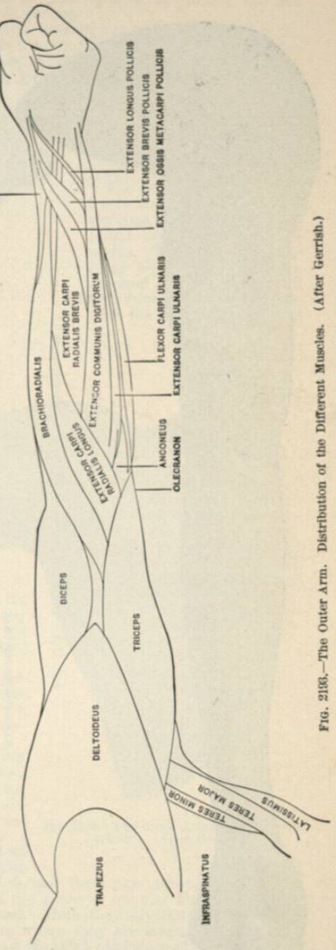

FIG. 2193.—The Outer Arm. Distribution of the Different Muscles. (After Gerrish.)

SUPERFICIAL NERVES.—The cutaneous nerves are the musculo-cutaneous, with a few fibres from the musculo-spiral near the elbow, for supplying the outer side of the forearm, front and back; the internal cutaneous, for supplying the inner side of the forearm, front and back. Lying between the two on the back of the forearm is the distribution of the lower (larger) cutaneous branch of the musculo-spiral. All these nerves pass the elbow. Behind, over a small area, limited to the olecranon, is the nerve of Wrisberg.

Piercing the fascia at the lower third of the forearm, the following nerves become superficial or cutaneous: the palmar branches of the ulnar median and radial nerves on the front, and the dorsal branch of the ulnar nerve and the radial nerve on the back.

The *brachial* (deep) *fascia* at the elbow is firmly fixed to the bony prominences, and is strengthened in front by the bicipital fascia. This slip is given off from the tendon of insertion of the biceps, which bridges over the brachial artery, and is lost over the pronator teres and its sheath at the inner side of the forearm. Some fascial fibres are also often received from the tendon of the triceps. Together in the upper third of the forearm this deep fascia

forms a strong enveloping sheath. Near the elbow at the internal condyle it serves in part as the origin of several muscles which spring from the condyle. Lower down in the forearm septa are given off from its deep surface to dip down between the various muscle bellies. In the lower third the fascia is continuous with the various muscle tendons and at the wrist forms the anterior and posterior annular ligaments. It ends in the fascia of the hand. It is attached to the posterior triangular area of the olecranon and to the whole of the posterior ridge of the ulna, and is much thicker behind. Between the superficial and deep layers of muscles, front and back, is a thin membranous layer of fascia. Below and behind. the fascia is strengthened by transverse fibres to form the posterior annular ligament of the wrist which passes from the anterior border of the radius above the styloid process backward and inward, over the series of ridges forming grooves for tendons, over the ulna serving as an orbicular ligament, to attach itself to the inner aspect of the wrist, especially over the pisiform and cuneiform bones.

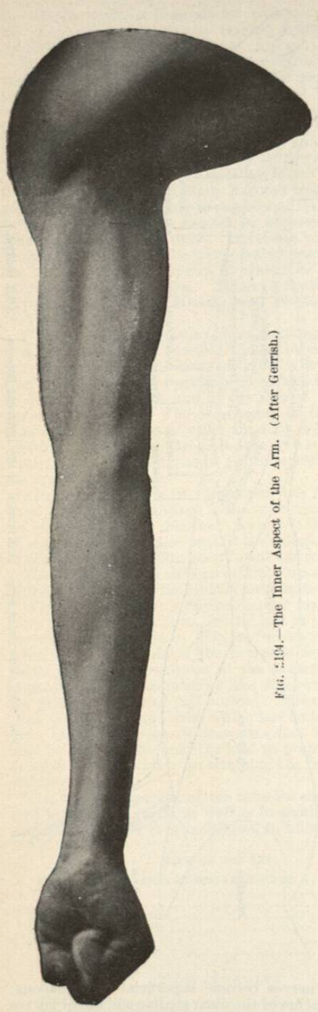

Fig. 2194.—The Inner Aspect of the Arm. (After Gerrish.)

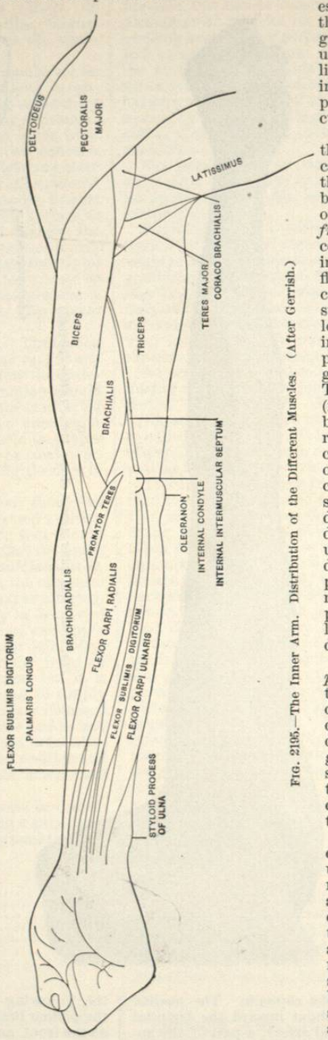

Fig. 2195.—The Inner Arm. Distribution of the Different Muscles. (After Gerrish.)

Muscles.—The muscles of the forearm, for convenience, can be divided into groups: those of the front, those of the back, and those of the outer side of the forearm. Those of the *front* (anterior radio-carpal) consist of a superficial set, five in number: the pronator teres, flexor carpi radialis, flexor carpi ulnaris, flexor digitorum sublimis, and (flexor) palmaris longus; and a deep set, three in number: flexor digitorum profundus, flexor pollicis longus, and pronator quadratus. The muscles of the *outer side* (radial), three in number, are: brachio-radialis, extensor carpi radialis longus, and extensor carpi radialis brevis. Those of the *back* (posterior radio-carpal) comprise a superficial set, four in number: extensor digitorum communis, extensor digiti minimi, extensor carpi ulnaris, and anconæus; and a deep set, five in number: supinator (brevis), extensor ossis metacarpi pollicis, extensor pollicis longus, extensor pollicis brevis, and extensor indicis.

The five muscles of the *superficial flexor* group are intimately associated at their origin from the internal condyle. Rising from it is a tendon common to them all, which gives fibres to each and sends septa between every two contiguous muscles. The muscles, from without inward, are the following:

The *pronator teres*, the most external, crosses obliquely the upper half of the forearm. It rises by two heads: one, large and superficial, from the inner condyle of the humerus, by a tendon common to both heads, and from the supracondylar ridge, fascia, and intermuscular septa; the other, a thin and deep band, coming from the inner side of the coronoid process and soon joining the deep surface of the large head. This slip separates the median nerve from the ulnar artery. The muscle thus formed passes outward and ends in a flattened tendon which turns over the radius and is inserted into a rough impression on the outer surface of the shaft of the radius about at its middle. Near the insertion the muscle is crossed by the radial artery and is covered by the brachio-radialis.

The *flexor carpi radialis* rises from the flexor tendon,

from fascia, intermuscular septa, and adjacent muscles. At about the middle of the forearm its fleshy belly merges into a long flattened tendon, passes in a special compartment of the anterior annular ligament, grooves the trapezium, and inserts itself into the base of the second and frequently into the third metacarpal bone.

The (*flexor*) *palmaris longus* is a long slender muscle, the smallest of the group. It rises from the flexor tendon, fascia, and septa, to form soon a small round belly. It soon ends in a long slender tendon which inserts itself into the lower border of the annular ligament and the palmar fascia. This muscle is very variable and is often absent.

The *flexor carpi ulnaris*, the innermost muscle of the group, rises by two heads: the one from the back part of the flexor tendon, the other from the inner side of the olecranon and, by an aponeurosis, from the upper two-thirds of the posterior border of the ulna. The two heads bridge the space between the internal condyle and the olecranon, and between and beneath them the ulnar nerve is transmitted. The muscle converges into a tendon which is placed along its front surface and inserts itself into the pisiform bone.

The *flexor digitorum sublimis* (flexor perforatus) is a broad flat muscle placed behind the preceding. It rises by a strong head from the flexor tendon, from the internal lateral ligament of the elbow joint, from the inner border of the coronoid process, and from the overlying muscles and septa; and by a second head, a thin flat band, from the anterior oblique line of the radius and its anterior border. It merges from a broad muscle into four separate tendons which first pass through the middle compartment of the anterior annular ligament, then diverge, and continue their course, each one separately, in company with a corresponding tendon from the profundus (behind), to each of the last four fingers. At the wrist the tendons pass in pairs, those for the third and fourth fingers being in front, those for the second and fifth lying behind the first pair. The tendons opposite the first phalanx divide, allow the profundus tendon to pass between, then unite behind to insert themselves into the second phalanx.

The *deep-seated flexor* group comprises the following muscles:

The *flexor digitorum profundus* (flexor perforans), a large thick muscle, rises from the upper three-fourths of the front and inner side of the ulna, from the ulnar half of the interosseous membrane, and from the aponeurosis of the flexor carpi ulnaris. It divides finally into four tendons for the inner four fingers, but the tendon for the index finger becomes distinct in the forearm. It passes behind the sublimis at the wrist, behind the sublimis tendons in the palm, and after perforating the sublimis inserts itself at the bases of the last phalanges of the inner four fingers. The lumbricales take origin from the tendons in the palm.

The *flexor pollicis longus*, to the outer side of the profundus, rises from the front of the radius between the oblique line and the pronator quadratus, and the adjacent interosseous membrane. From a fleshy belly, a round tendon passes under the annular ligament and thenar eminence to its insertion at the base of the second (last) phalanx of the thumb. Occasionally a second head rises from the coronoid process or internal condyle in common with the sublimis.

The *pronator quadratus* rises from the pronator ridge and from the front of the ulna at its lower fourth, passes close to the bones, and inserts itself into the front of the lower end of the radius.

The muscles of the *outer* (radial) *extensor* group are:

The *brachio-radialis* (supinator longus) rises from the upper two-thirds of the external supracondylar ridge and from the front of the external intermuscular septum. It forms a long slender muscle which, near the middle of the forearm, merges into a flat tendon; and this, in turn, inserts itself into the outer side of the radius near the base of the styloid process.

The *extensor carpi radialis longus* rises just below the preceding muscle fom the ridge and septum, a few fibres being derived from the common extensor tendon. From this origin a long tendon passes under the posterior annular ligament in its second compartment and passes to its insertion into the base of the second metacarpal. In its course it lies upon the following muscle.

The *extensor carpi radialis brevis* rises by the common extensor tendon from the external condyle of the humerus, from the intermuscular septa, and from the external lateral ligament of the elbow. Its tendon passes with the longus in the same compartment at the wrist and is finally inserted into the base of the third metacarpal.

Fig. 2196.—The Inner Arm. Muscles contracted. (After Gerrish.)

The *superficial extensor* group, from without inward, contains the following muscles:

The *extensor digitorum communis* rises by the common extensor tendon, fascia, and septa. From a fleshy belly four tendons are ultimately given off, and these pass through the fourth compartment of the posterior annular ligament on their way to the hand. Here they diverge and then pass on to the points where they are inserted at the bases of the second and the third phalanges of the inner four fingers.

The *extensor digiti minimi* lies at the inner side of the preceding muscle. It rises in the same manner as does the latter and passes through the fifth compartment at the wrist (between radius and ulna); its points of insertion are the same as those of the corresponding tendon of the preceding muscle.

The *extensor carpi ulnaris* rises in the same manner as the preceding, and also by an ulnar aponeurosis common to it, the flexor carpi ulnaris, and the flexor profundus. The tendon emerges near the wrist, passes in the sixth

compartment, and is inserted into the base of the fifth metacarpal near its ulnar border.

The *anconæus* rises from the lower part of the back of the external condyle and from the adjacent posterior ligament of the elbow and is inserted into the outer surface of the olecranon and the upper third of the back of the ulna. This muscle is sometimes continuous with the triceps and is usually described in connection with it, as a fourth head.

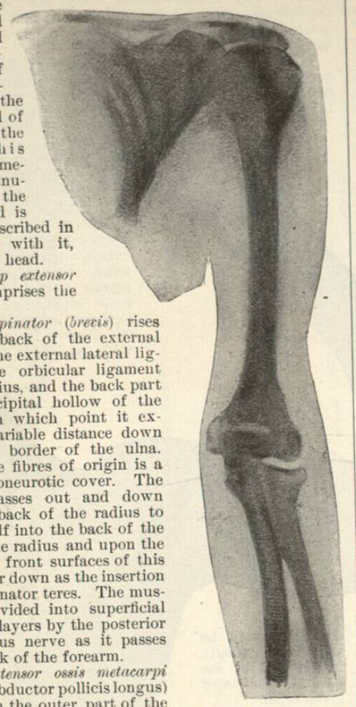

Fig. 2197.—Skiagraph Showing Relations of Bony Framework of the Shoulder, Arm, and Elbow to the Soft Parts which Surround Them. (After Gerrish.)

The *deep extensor* group comprises the following:

The *supinator* (*brevis*) rises from the back of the external condyle, the external lateral ligament, the orbicular ligament of the radius, and the back part of the bicipital hollow of the ulna, from which point it extends a variable distance down the outer border of the ulna. Over these fibres of origin is a strong aponeurotic cover. The muscle passes out and down over the back of the radius to insert itself into the back of the neck of the radius and upon the outer and front surfaces of this bone as far down as the insertion of the pronator teres. The muscle is divided into superficial and deep layers by the posterior interosseous nerve as it passes to the back of the forearm.

The *extensor ossis metacarpi pollicis* (abductor pollicis longus) rises from the outer part of the back surface of the ulna at the junction of the upper and middle thirds, from the corresponding portion of the interosseous membrane, from a small part of the back of the radius near its middle, and from intermuscular septa. The muscle extends down and out, emerges between the extensor digitorum communis and the extensor carpi radialis brevis, and in company with the extensor pollicis brevis it crosses the two radial extensors. At about this point it merges into its tendon, follows down the outer side of the base of the radius, and enters the first compartment of the posterior annular ligament. It is inserted into the outer side of the base of the first metacarpal bone and by its aponeurosis into neighboring structures, notably the back of the trapezium, and also into the palmar fascia, especially that part which covers the thumb.

The *extensor pollicis brevis* (extensor primi internodii pollicis) rises from the middle of the back of the interosseous membrane just below the preceding, from the back of the radius extending obliquely outward and downward, and from the intermuscular septa of this group of muscles. It extends obliquely down and out and forms its tendon at the lower third of the forearm. From this point it accompanies the tendon of the preceding muscle, lying behind it, to be inserted into the base of the first phalanx of the thumb.

The *extensor pollicis longus* (extensor secundi internodii pollicis) rises from the outer part of the back of the ulna at its middle third, close to the outer border, from the interosseous membrane, and from the septum between it and the extensor indicis. This muscle, somewhat stronger than the preceding, passes down and out to merge into a tendon placed along its back. The tendon becomes free just above the posterior annular ligament, passes through its third compartment, then over the radial extensors, lies close to the inner side of the tendon of the preceding, and is inserted into the base of the second phalanx of the thumb.

The *extensor indicis* rises from the back of the ulna (from a point just below the preceding muscle to one situated nearly at the lower end of the bone), from the adjacent interosseous membrane, and from the septum between it and the preceding. It merges into a tendon which is placed along its radial border. This becomes free at the lower third of the forearm, passes through the fourth compartment beneath the tendons of the extensor digitorum communis, and after it emerges from this it is inserted into the inner border of the tendon of the common extensor of the index finger at about the metacarpophalangeal joint.

Arteries.—The *brachial artery* ends just below the bend of the elbow where it divides opposite the neck of the radius into its two terminals, the radial and the ulnar.

The *radial artery*, the smaller of the two, extends downward, in direct continuation of the brachial artery, along the outer side of the front of the forearm to the lower end of the radius. Here it turns around the outer side of the radius to the back of the wrist, over the external lateral ligament, and under the extensors of the thumb.

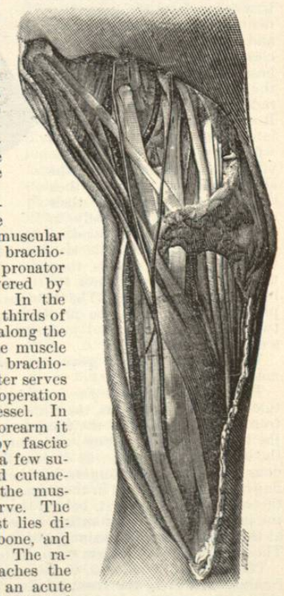

Fig. 2198.—External and Posterior Region of Wrist, showing Arrangement of Tendons, Artery, Nerve, etc. The skin and fasciæ have been removed. (Reduced in size.) (After M. H. Richardson.)

In the upper forearm it lies in the outermost intermuscular space between the brachio-radialis and the pronator teres, and is covered by fasciæ and skin. In the middle and lower thirds of the forearm it lies along the inner border of the muscle and tendon of the brachio-radialis, which latter serves as a guide in the operation for ligating this vessel. In this part of the forearm it is covered only by fasciæ and skin, and by a few superficial veins and cutaneous branches of the musculo-cutaneous nerve. The radial at the wrist lies directly upon the bone, and forms the pulse. The radial nerve approaches the artery above at an acute angle; in the middle and lower thirds it lies along its outer side. The venæ comites accompany the artery on either side.

The radial artery in the forearm, besides the irregular and numerous muscular branches, gives off the radial recurrent, the anterior radio-carpal, and the superficial volar.

The *radial recurrent*, a branch of considerable size, is usually given off from the outer side of the radial just below its origin from the brachial. It runs outward between the brachio-radialis and the supinator (brevis), divides into several branches and anastomoses with the interosseous recurrent and superior profunda, and gives off a branch to supply the elbow joint.

The superficial volar and the anterior radio-carpal are branches given off just above the wrist.

The *ulnar artery*, the larger of the terminals of the brachial, from the inner side of the neck of the radius passes down and inward to the front of the inner (ulnar) side of the forearm, thence directly to the wrist, and over the anterior annular ligament to the palm.

In the upper half of its course the artery lies deeply beneath the pronator teres and the superficial flexors; in the lower half of the forearm it is overlapped only by the flexor carpi ulnaris muscle and tendon which lie to its inner side and serve as a guide in operations for ligating the vessel. Only in the last inch or so is the artery superficial. As the artery lies beneath the pronator teres it is crossed from within outward by the median nerve, the deep head of the muscle usually separating the two. The ulnar nerve approaches the artery from behind the inner condyle at an acute angle, being separated from it by the flexor sublimis, and in the lower two-thirds it lies close to the inner side of the artery. The latter is covered by superficial ulnar veins, in addition to fasciæ and skin, and is crossed by branches of the internal cutaneous nerve. The artery is accompanied by two venæ comites.

The ulnar artery, besides numerous and irregular muscular branches, gives off the anterior and posterior recurrent ulnar, the anterior and posterior interosseous, the anterior and posterior ulnar carpal, and usually the nutrient of the ulna.

The *anterior recurrent ulnar*, the smaller of the two recurrent branches, runs up in front of the inner condyle of the humerus, between the pronator teres and the brachialis, and anastomoses with the anterior branch of the anastomotica magna and a branch of the inferior profunda.

The *posterior recurrent ulnar*, the larger, passes inward between the flexor sublimis and the flexor profundus, then up and back of the inner condyle of the humerus, and comes to lie, with the ulnar nerve, between the two heads of the flexor carpi ulnaris. It anastomoses with the posterior branch of the anastomotica magna, with the inferior profunda, and with the interosseous recurrent to form the olecranal rete.

The *interossei* rise from the ulnar by a common trunk about half an inch in length, and the latter, in turn, rises from the outer and back part of the ulnar just before the median nerve crosses the main vessel. It rises about an inch below the origin of the ulnar, and proceeds backward to the interosseous membrane, where it divides into its two terminals.

The *anterior interosseous*, the smaller, follows the front of the membrane in company with two veins and the deep branch of the median nerve which lies to its outer side. It usually supplies nutrients to both bones.

The *posterior interosseous*, the larger, passes back between the interosseous membrane and the oblique ligament above, descends between the superficial and deep muscles, and, crossing the extensors of the thumb and index finger, anastomoses below the latter muscle with the anterior interosseous.

The anterior and posterior ulnar carpals are small carpals which, in company with the anterior radial carpal, anastomose and form the carpal arch.

Nerve Trunks.—The nerve trunks of the forearm are the radial, posterior interosseous, median, and ulnar.

The *musculo-spiral* nerve, a short distance above the elbow, lying upon the brachialis and covered by the brachio-radialis, divides into its terminals, the posterior interosseous and the radial nerves.

The *posterior interosseous* nerve passes back, out, and down between the brachialis and extensor carpi radialis longus, through the supinator (brevis), to the deep layer of the forearm extensors. It approaches the posterior interosseous artery at an angle, and is in relation with it as far as to a point below the origin of the extensor pollicis longus where it approaches and is in relation with the posterior branch of the anterior interosseous artery. Lower down, it passes through the fourth compartment of the wrist, with the extensors communis and indicis, to the back of the wrist where it becomes ganglionic.

The *radial* nerve passes directly downward under cover of the brachio-radialis. At the middle third of the arm it lies along the outer side of the radial artery, then winds around the outer side of the radius under cover of the brachio-radialis tendon, and pierces the deep fascia in the lower forearm, breaking up into its terminal branches on the back of the wrist.

The *median* nerve, from the bend of the elbow, where it lies to the inner side of the tendon of the biceps, the

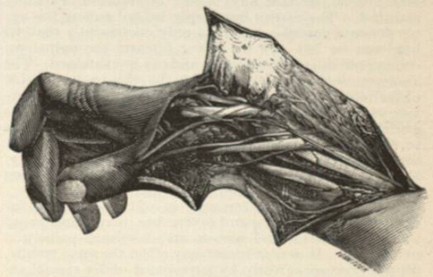

Fig. 2199.—Dissection of the External Region of the Right Wrist. The radial artery is seen between the relaxed tendon of the flexor carpi radialis below, and the brachio-radialis on the outer (upper) side. It then passes beneath the first two extensors of the thumb and a small branch of the radial nerve, crosses the base of the thumb obliquely, and disappears under the tendon of the extensor pollicis longus. (Thin subject, female, one-half normal size.) (After M. H. Richardson.)

brachial, and the beginning of the ulnar artery, passes down the centre of the front of the forearm beneath the condylar head of the pronator teres and over the ulnar artery, being separated from the latter by the deep head of the same muscle. Beyond this point it passes beneath the radial head of the flexor digitorum sublimis, and later still it lies deep beneath the flexor sublimis and on the flexor profundus. At the wrist the nerve becomes superficial and lies between the tendons of the flexor sublimis to the inner side, and of the flexor carpi radialis on the outer side. It passes superficially through the large flexor compartment of the anterior annular ligament and soon divides into an inner and an outer terminal. Besides muscular branches in the forearm, the median gives off the anterior interosseous and small branches to the elbow joint.

The *anterior interosseous* nerve is given off from the median opposite the insertion of the biceps, runs down the front of the membrane in company with the anterior interosseous artery, and supplies the medullary arteries, the periosteum of the radius and ulna, and the wrist joint.

The *ulnar* nerve, from the angle between the olecranon and the internal condyle, passes between the inner and outer heads of the flexor carpi ulnaris to the front of the forearm. It passes down upon the flexor profundus under cover of the flexor carpi ulnaris and overlapped by it upon the inner side. It passes nearly to the wrist along the outer side of this muscle and its tendon, when it becomes superficial and enters the hand anteriorly to the annular ligament. In the lower two-thirds of the forearm the ulnar artery lies to its outer side, separating it from the flexor sublimis. It also, besides giving off muscular branches, supplies the elbow joint.

The *interosseous membrane* bridges across between the interosseous borders of the radius and ulna, from a point a little below the bicipital tubercle of the radius to the wrist joint. Its fibres pass mainly in an oblique direc-

tion from the radius to the ulna. The posterior interosseous vessels pass back over its upper border and are in relation with its back surface low down in the forearm. The anterior interosseous vessels and nerve are in relation with the front surface throughout. Except in supination of the forearm and in full pronation this membrane is usually tense. It serves also to carry strains from the radius to the ulna and to bind the bones together.

The forearm is subconical, so that the lateral flap operation is a necessity, since the skin cannot be pushed far upward in the lower forearm. The skin is, also, quite adherent to the underlying aponeurosis. Roughly speaking, the intermuscular septa, the bones, and the interosseous membrane form a front and a back compartment. The *ulna* is subcutaneous from olecranon to styloid process, so that any injury or fracture is readily manifest. The *radius* lies deeply lodged among the upper forearm muscles and it is only occasionally that its head can be felt. In the lower forearm the radius becomes gradually subcutaneous and can be examined. The *interosseous membrane* is relaxed in the semi-prone position of the forearm, which indicates the best position, in fracture of the radius or ulna, for splinting. Care should be exercised not to permit the fractured ends of the radius to rest upon the ulna, thereby causing injury to interosseous vessels and nerves and favoring an eventual ankylosis. Antero-posterior splints may press too much upon radial and ulnar vessels and nerves and injure them.

The *muscles* of the forearm, in extremely muscular subjects after too long and severe use, may cause pressure upon arteries and nerves, and resultant pains and neuralgias. Muscular spasm may effect the same results. Muscles become greatly hypertrophied under special exercises (as occurs, for example, in the pronator teres muscle of the "tennis arm"). A spasm of the same muscle may take place, as in the "glass arm" of baseball pitchers. Hypertrophy of both of the pronators, the result of "feathering," may take place in the case of oarsmen. The inner edge of the brachio-radialis is the guide to the *radial artery* and nerve; the inner edge of the palmaris tendon is that for the *median nerve;* and the outer border of the flexor carpi ulnaris indicates where the *ulnar artery* and nerve are to be sought for. Both arteries may be ligated at any point above the annular ligament for severe hemorrhage of the palm. Above the anterior annular ligament the two synovial tendon sheaths of the flexor pollicis longus and that common to the sublimis and profundus extend for a distance of an inch and a half, and often carry infection from the palm to the tendon spaces of the forearm.

Through the posterior annular ligament extend upward six such sheaths, all of which save the last extend well above the ligament. They are: one for the two outer thumb extensors, one for the two radio-carpal extensors, one for the long thumb extensor, one for the common extensor, one for the little finger extensor, and lastly one for the ulno-carpal extensor.

Injuries of the *nerve* trunks may cause varying symptoms. (Compare *Arm.*) The *posterior interosseous nerve* may be injured in resection of the head of the radius or in fracture of the radial neck, and thus may cause paralysis of the extensors. The posterior interosseous nerve may suffer loss of function from fracture of the humerus at some point near its middle. Pressure upon the *median nerve* in muscular spasm and in compression from long and severe muscular exercise, may cause increased cramps and pain or even a prolonged neuralgia. The *ulnar nerve* may be injured in fracture of the olecranon and may cause loss of sensation, or numbing; or it may be caught in the callus of fracture, either there or along the shaft of the ulna, and cause pain; and, finally, the conditions may be such as to necessitate excision of the nerve from the callus. The numbness from a sudden blow upon the ulnar nerve at the elbow —commonly spoken of as "striking the funny bone"— is a familiar instance; and if severe, this numbing and tingling may be persistent and may be accompanied by loss of function of the flexor muscles. In plumbism the ulnar nerve is regularly involved, causing the "claw hand." The ulnar and median nerves are both involved in alcoholic neuritis. The *radial nerve* may be painful at its points of distribution if the trunk is injured in Colles' fracture. Neuromata along the nerve trunks, due to injury, may demand excision.

Luzerne Coville.

References: Joessel, Quain, Morris, Gerrish, Keen, Holden, Cunningham, Gray.

FORMALDEHYDE, formic aldehyde, methyl aldehyde or oxymethylene (HCOH), is a gas whose saturated aqueous solution is known as *formalin* or *formol*. The method of manufacture used now on a large scale is a modification of that used by A. W. Hoffmann, who introduced formaldehyde in 1867. By means of superheated steam passing through a copper coil, methyl alcohol is vaporized under pressure in a steel chamber, from which it issues with great force and mixed with a definite quantity of air, and then passes through a double tube converter. The inner tube of this is perforated with very fine holes and separated from the outer tube by broken coke, and the whole is kept at a dull red heat. As it passes through this heated coke, the vapor is oxidized to formaldehyde, and this is either condensed by extreme cold to a liquid, or cooled and dissolved in water by agitation. Copper filings, spongy platinum, or any porous material may be substituted for coke. The gas is usually generated on a small scale by heating paraformaldehyde, though methyl alcohol can be employed by heating in a tin vessel so that the vapor will pass through a perforated red-hot copper plate. The reaction is: $CH_3OH + O = CHOH + H_2O$. The yield is said to be only twenty per cent. from commercial wood alcohol. Other methods of manufacture are by the complete oxidation of ethyl nitrate; by heating a mixture of ethylene and oxygen to 400° C.; by the dry distillation of calcium formate, etc.

Formaldehyde is a colorless gas of pungent, penetrating odor, and very irritating to the eyes and nose. Its saturated cold aqueous solution (formalin) contains from thirty-five to forty per cent. of the gas by weight, is colorless, has a sharp taste, and mixes freely with water, alcohol, and glycerin. The gas is more soluble in methyl alcohol than in water. Its chemical affinities are extensive. It is rendered inert by alkalies, deodorizes hydrogen sulphide, and is the basis of many aniline colors and new synthetic remedies, such as urotropin, bismal, tannoform, etc. It reduces Fehling's solution, produces a black precipitate with ammoniacal silver-nitrate solution, and white precipitates with dilute aqueous solution of aniline and with ammonia and bromine water. Henner's test, sensitive 1 in 200,000, consists in superposing a mixture of very weak carbolic acid with the suspected liquid upon concentrated sulphuric acid; a rose-violet ring at the line of contact indicates formaldehyde. A modification of this is to dissolve 0.1 gm. morphine hydrochlorate in 1 c.c. of sulphuric acid and add to this the suspected liquid. In milk and such fluids, however, these tests may be obscured by the charring of the organic substances by the acid; hence, in such a case, the formaldehyde should be distilled off and passed into water, and then tested for. Jorrissen's test was designed for milk: shake together 25 c.c. of milk and 10 c.c. of 0.1 per cent aqueous phloroglucin, add 5 to 10 c.c. of one-third strength potash lye, and a transient salmon-red color indicates formaldehyde.

When formalin is heated, part of it is converted into paraformaldehyde (paraform, triformol, or trioxymethylene), which separates as a white insoluble flocculent mass, capable of again yielding HCOH gas. Formaldehyde renders gelatin insoluble, forming elastic translucent masses, so it has been used to replace tannin in making leather and to harden gelatin films in photography. Formaldehyd-gelatin is employed as an absorbable antiseptic. When added to serum albumin, formalin prevents coagulation by heat; added to calcium carbide, it retards the evolution of acetylene gas. It neutralizes

alkalies by forming with them complex substances, that with ammonia being hexamethylene-tetramine.

It is said not in any way to affect the textile character of wool, cotton, fur, silk, or leather; and it does not change their colors except in the case of iron-containing dyes or a few of the aniline colors such as fuchsin (aniline red). Its aqueous solution attacks metals; consequently the dry gas only should be used for sterilizing instruments. In 1886 its powerful bactericidal properties were reported by Loew, and it has now become an almost universal disinfectant (see *Disinfectants* and *Disinfection*). Rubber goods, catheters, etc., may be kept sterile in a weak solution for a long time without harm. Hoffmeister, Hirst, and others have used it for sterilizing catgut.

It is also used largely as a hardening and fixing agent, and as a preservative for anatomical and biological specimens. These, especially plants, tend to retain some of their brilliant colors, and do not shrink as they would in alcohol. Plants slowly discolor the solution by giving up their tannin. As formaldehyde has little penetrating power, openings should be made so that it may permeate the interiors of specimens; otherwise they may rot, even in strong solution. Moulds have been found growing on tissues apparently saturated with solutions of five to ten per cent. strength. Orth's hardening and fixing formula is: Müller's fluid, 100 parts; formalin, 10 parts. To be mixed just before use. Kaiserling keeps the specimen for twenty-four hours in formalin 75, potassium nitrate 1, potassium acetate 3, distilled water 100, then transfers to 80-per-cent. alcohol for twelve hours, then to 95-per-cent. alcohol for two hours. The specimen may then be mounted for sectioning, or kept in equal parts of water and glycerin containing 3 per cent. of potassium acetate. Before putting through alcohol, Carter leaves the tissues for from six to twelve hours in 20-per-cent. formaldehyde solution with 5 per cent. acetic acid. Blood smears exposed to the vapor are firmly fixed, and may be stained as by any other method of fixing. Blood on the hands becomes hardened and difficult to wash off.

Being difficult of detection in small quantities, it is used as a preservative of foods and medicines, vigorous prohibitive laws not preventing its widespread use by dairymen, canners, etc. In the strength of 1 to 20,000 it is said to preserve milk for several days, yet even this minute quantity has been shown by Annett and others to be harmful. It has been employed by pharmacists for the preservation of ointments, syrups, fruit juices, infusions, and various other articles which readily spoil. Mucilage of acacia, lard, cider, etc., remained sweet after a year, yet the odor of formaldehyde could not be detected at any time. Once added to an article, a portion of it remains persistently and cannot be driven off by heat. The best means of neutralizing it in vapor or in solution is by ammonia.

Physiological Action and Toxicology.—Formaldehyde vapor is a powerful irritant to the eyes and the mucous membranes of the respiratory tract. Applied in solution to the skin it smarts, but usually for a short time only. Severe urticaria is reported to have followed its application. The solution in glycerin is said to be less irritant. Taken by mouth it retards digestion even in small dosage, especially the pancreatic digestion of albumin. In strong solution it may cause vomiting. It weakens pulse and respiration and is depressing to the vital functions. The ingestion of several ounces of formalin by an adult was followed by unconsciousness, marked pallor, cold clammy perspiration, increased respiration, and râles over both lungs. The urine contained formic acid. In a few hours anuria developed, and the next morning the coma disappeared, and the patient acted as if drunk, complaining of headache, conjunctivitis, and a sore mouth. He recovered in twenty-four hours (Klueber). In England, the drinking of two ounces of a four-per-cent. solution resulted in death from heart failure twenty-nine hours later. The autopsy showed corrosive action on the œsophagus and stomach. Fischer (1901) reported to the Chicago Pathological Society an experimental study of the action of formaldehyde on animals. Inhalation resulted in marked inflammation throughout the respiratory tract. Dosage by stomach produced vomiting, subnormal temperature, rapid weak pulse, and death. Sometimes the death was sudden. Necropsy revealed intense gastritis, with congestion, necrosis, and leucocyte infiltration. Intraperitoneal injections were followed by a fibrino-hemorrhagic peritonitis of an intensity referable to the strength of the solution. Small repeated intraperitoneal injections of dilute solutions stimulated great connective-tissue proliferation. Eye instillations caused iritis. Every case showed early eosinophilia followed by general leucocytosis, and degenerative changes with focal necroses in liver and kidneys. Experiments in France show that fleas easily succumb to the vapor, but that to kill rats and mice requires as much as 8 or 10 gm. to the cubic metre of air space.

The best local antidote is ammonia, though other alkalies are of some avail. Ammonia gas quickly neutralizes the irritating vapors in a room. For the stomach it may be given as the aromatic spirit of ammonia or the liquor ammonii acetatis. When formalin is swallowed, vomiting should be promoted, or the stomach emptied by lavage. Stimulants, especially aromatic spirit of ammonia and caffeine, and hypodermics of strychnine should be administered, external heat applied, and absolute recumbency enjoined. Demulcent drinks may be given to allay irritation.

Therapeutics.—As a general disinfectant and deodorizer this drug is undoubtedly without a peer, though its penetrating power is not great (see *Disinfection*). In the respiratory passages it is of pronounced value as a prophylactic and curative in *influenza* and *pertussis*, and in allaying the cough and sweetening the sputum in *tuberculosis*. It is also used in *chronic pharyngitis*, in *atrophic rhinitis* (principally as a deodorizer), and as a *mouth wash*. It is said to be of less use in *diphtheria*, as it does not penetrate the dense membrane. A few drops of ℞ Aq. chloroformi ʒ iij. (12 c.c.), ether ℥ ss. (15 c.c.), formaldehyde solution (6 per cent.) ad ℥ iv. (120 c.c.) may be sprinkled on the sponge of a zinc respirator, and inhaled for fifteen minutes. Or one can use as a mouth wash or spray a mixture of 40-per-cent. formaldehyde solution ʒ i. (4 c.c.), glycerin ʒ iv. (15 c.c.), and water to make ℥ iv.–vi. (120 to 180 c.c.). The method of treating *tuberculosis* by cataphoresis or the electrical transmission of formaldehyde directly into the human body, the writer saw tested scientifically with negative results.

For *suppurative otitis media* Reik recommends irrigation twice a day with ʒ i. (4 c.c.) of formalin in O i. (500 c.c.) of water. Ward uses five to ten drops of a one-per-cent. solution, and in *acute otitis* three drops at a time.

In the mycotic skin diseases, such as *sycosis*, *ringworm*, and *favus*, the strong solution may be applied every other day. Cures resulted from one to four applications (Salter, Daniel). For *seborrhœa* Ravogli advises rubbing with ℞ Formalin, ʒ i.–ij. (4–8 c.c): glycerin, ʒ ij. (8 c.c.); aq. coloniensis, alcohol, āā ℥ iij. (90 c.c.).

Hyperidrosis pedis may be checked for a week or two (Hahn, Hirschfeld) by momentarily immersing the feet in pure formalin, or by applying it with a brush. Unna applies adeps lanæ 20, vaseline 10, formalin 10–20. The application of formalin to eczema or intertrigo Unna found to be very painful. He then tried a gelatin mask hardened with formalin for lupus, erythema centrifugum, lepra, and obstinate chronic eczema, but was obliged to discard it. Next he employed formalin as a corrosive for carcinoma, lupus, condylomata, and ulcers. The diseased tissues were cleanly destroyed, the necrotic surface being dry and odorless, but the development of a line of demarcation took so long a time that other means were deemed preferable. He found formalin of value, however, in *inoperable carcinoma*, as it deodorizes and mummifies the part. For *condylomata* and other soft skin protuberances he uses paraform collodion, which possesses the advantage of keeping the growths dry. Daniel rubs

formalin into *warts* with a stick, and these shrink and come off without leaving a scar.

As a vaginal douche Crawford recommends formalin in *obstetrics*, and Van Winckel uses ʒ i. (4 c.c.) to a quart (1 litre) for *endometritis* or for *vaginitis*, especially gonorrhœal. It may be used in full strength in the treatment of *chancroids*.

Surgically it is an antiseptic of great power (see *Disinfectants* and *Disinfection*), and is used for sterilizing the hands, dressings, sutures, and instruments. Hoffmeister, Hirst, and others recommend it highly for catgut. Hoffmeister's method is to harden the catgut on glass spools in four per cent. formaldehyde for twenty-four hours, then boil in water for ten minutes and keep in alcohol containing five per cent. of glycerin and 0.1 per cent. of corrosive sublimate. Vandermarker states that it should not be used directly in wounds, as one-per-cent. solutions will destroy fresh granulations, and two-per-cent. will produce sloughs. Its combination with gelatin (glutol), however, is used thus by Schleich and others. Inoperable epitheliomata and sarcomata have been treated with injections of one-half-per-cent. solution (about twenty minims) followed by curetting of the hardened tissue. The bleeding has been slight, and the growths have practically disappeared after a few treatments (Mitchell, Thompson). Ravogli claims to obtain the same results from the application of a paste of rice powder, oxide of zinc, and formalin. In chronic tuberculous joints, tuberculous abscesses, and empyema, Hahn considers a one-per-cent. glycerin solution to be more efficient than the much used iodoform-glycerin.

In dentistry, paraformaldehyde is preferred, as, being in solid form, it can be placed in cavities, disinfecting them by slowly evolving formaldehyde gas.

The more common preparations and compounds of formaldehyde are:

Aminoform, Ammonio-formaldehyde—synonyms for hexamethylene-tetramine.

Amyloform—starch and formaldehyde (see Vol. I.).

Bismal—the bismuth salt of methylene digallic acid, formed by the action of gallic acid on formaldehyde. Used as intestinal antiseptic and astringent.

Creoform, Creosoform, Kreoform—a non-toxic, tasteless, and odorless compound of creosote and formaldehyde. A strong antiseptic.

Cystamine, Cystogen—synonyms for hexamethylene-tetramine.

Dextroform—formaldehyde and dextrin (see *Amyloform*, Vol. I.).

Eka-iodoform—iodoform and paraformaldehyde (see Vol. III.).

Euformol is a mixture of oil of eucalyptus, formaldehyde, thymol, menthol, etc.

Formacoll—synonym for glutol.

Formaldehyd-bisulphite (HCOH, $Na_2S_2O_5$) is a crystalline mixture resulting from the action of formaldehyde on sodium bisulphite in solution. It is claimed to possess the antiseptic properties of both constituents.

Formaldehyde-casein (Formalbumin) is an odorless, tasteless, coarse yellow powder, used in surgery as an antiseptic.

Formaldehyde-gelatin—used in photography and in surgery (see *Glutol*).

Formaldehyde-sulpho-carbolic acid [$(CH_2OH)_2.C_6H_3.OH$] is used as an antiseptic dressing for wounds.

Formaldehyde tannalbuminate—tannalbumin subjected to the action of formaldehyde to render it more resistant to the action of the gastric juice. The compound passes unchanged through the stomach, and as it is split up but slowly in the intestines, it gets well down in the bowel before it separates into its components. Used as an intestinal antiseptic and astringent.

Formaldehyde-urea is an amorphous, white condensation product of urea and formaldehyde in alkaline solution. It is insoluble in water. Used as disinfectant.

Formalin, Formol—a saturated aqueous solution of formaldehyde.

Formatol is a proprietary dusting powder containing formaldehyde.

Formin—synonym for hexamethylene-tetramine.

Formo-chloral is an oily compound formed by the action of formaldehyde on chloral in the presence of concentrated sulphuric acid. It is used as an antiseptic.

Another compound of this name, used by Trillat as a deodorizer, is made by acting with calcium chloride on formaldehyde in solution in methyl alcohol.

Formoforin consists of formaldehyde 0.18, thymol 0.10, zinc oxide 34.44, and starch 65.28 per cent., and is used for sweating of the feet.

Formopyrin occurs in white crystals formed by the action of formalin on a solution of antipyrin. It is insoluble in cold water or ether, but fairly soluble in boiling water, alcohol, chloroform, and acids, with the latter forming stable salts.

Fortoin—cotoin acted upon by formaldehyde (see *Fortoin*).

Galloformin is prepared by acting on hexamethylene tetramine with gallic acid (see *Galloformin*).

Geoform—guaiacol and formaldehyde (see *Geoform*).

Glyco-formol is a mixture of formalin, water, and glycerin.

Glycero-formol is said to be formed by the prolonged action of formaldehyde on glycerin. It is claimed to be more toxic than formaldehyde, but the writer could find no evidence for this statement.

Hexamethylene-tetramine—the chemical name for aminoform, cystamine, cystogen, formin, and urotropin (see Urotropin).

Holzin is a sixty-per-cent. solution of formaldehyde in methyl alcohol used by Oppermann as a deodorizer.

Holzinol is a mixture containing formaldehyde and menthol.

Krameroform is prepared like tannoform, but from rhatany-tannin.

Lanoform is lanolin containing one per cent. of formaldehyde.

Lysoform is a soapy disinfectant containing formaldehyde (see *Lysoform*).

Naphthoformin is made from paraformaldehyde and the alpha and beta compounds of naphthol. It is used both externally and internally as an antiseptic.

Paraform is paraformaldehyde.

Polyformin Soluble and Insoluble—used in skin diseases (see *Polyformin*).

Preservalin—a mixture used by dairymen.

Protogen is an albuminous food obtained by acting on serum or egg albumen with formaldehyde. It is not coagulated by heat.

Quebrachoform, Quinoform, Querciform are prepared like tannoform (which see), but from the tannins of quebracho, cinchona, and oak.

Saligenin, also yielded by salicin, may be obtained by the interaction of phenol and formaldehyde.

Steriform Chloride and *Iodide*—formaldehyde 5, pepsin 20, lactose 65, and ammonium chloride or iodide 10.

Tannoform—an antiseptic in skin diseases (see *Tannoform*).

Tannopin or *Tannon* consists of tannin and hexamethylene-tetramine, and is used in diarrhœa (see *Tannopin*).

Thymoform is thymol-formaldehyde (see *Thymoform*).

Triformol, Trioxymethylene—synonyms for paraformaldehyde.

Urotropin—hexamethylene-tetramine (see *Urotropin*).

W. A. Bastedo.

FORMANILID ($C_6H_5NH.COH$) occurs in long, colorless prismatic needles obtained by digesting aniline with formic acid, or by rapidly heating aniline and oxalic acid together. It melts at 46° C. (115° F.), and is soluble in water, alcohol, glycerin, and oils. In dose of 0.13–0.3 gm. (gr. ij.–v.) it is antipyretic and analgesic, but is said to depress the heart and produce cyanosis. Its chief employment is as a local anæsthetic in two-per-cent.

solution, as in genito-urinary inflammation, or subcutaneously, or in powder form, mixed with chalk, starch, or talcum, or as a snuff in nasal troubles. *W. A. Bastedo.*

FORMIC ACID.—$HCHO_2$. Formic acid is a heavy, colorless fluid of a sharp, sour odor and taste, soluble in all proportions in water, alcohol, and glycerin. It is exceedingly irritating, producing, when applied to the skin, redness, blistering, and even sloughing, and, taken internally, gastro-enteritis and bloody urine. It has been used occasionally, locally, as a counter-irritant, applied diluted with an equal measure of water.

Edward Curtis.

FORT CRAWFORD MINERAL WELL.—Crawford County, Wisconsin.

Post-Office.—Prairie Du Chien. Hotel.

Access.—Viâ Chicago, Burlington and Quincy, and Chicago, Milwaukee and St. Paul Railroads. Prairie du Chien contains about 4,000 inhabitants, and is one of the oldest towns in the State. The well from which the mineral water is obtained was bored in 1876. At a depth of 960 feet a strong flow of water was encountered, and ever since there has been a continuous stream, six inches in diameter and having a pressure of twenty pounds to the square inch. The well yields about 40,000 gallons per hour. By means of mains and hydrants it furnishes the city fire department, and affords an abundance of water for domestic purposes. It was soon learned that the water possessed medicinal qualities. An analysis by Professor Bode, of Milwaukee, showed the following results:

One United States Gallon Contains:

Solids.	Grains.
Calcium bicarbonate	0.62
Magnesium bicarbonate	10.97
Sodium chloride	90.20
Potassium chloride	3.80
Sodium bromide	.13
Sodium sulphate	12.80
Calcium sulphate	15.38
Iron bicarbonate	.23
Sodium phosphate	Trace.
Sodium bicarbonate	Trace.
Alumina	.66
Silica	3.84
Organic matter	None.
Total	138.63

This is a valuable member of the widely useful alkaline-saline class of waters. It closely resembles some of the Saratoga waters in its mineral constituents, being, however, somewhat milder than those waters. Its chief effects are antacid, laxative, diuretic, and tonic. It is well adapted for the class of diseases to which such waters are applicable. It is also an excellent table water. A well-equipped sanitarium with ample bathing facilities is conducted in connection with the well. The water is used commercially. *James K. Crook.*

FORTOIN, or methylene-dicotoin [$CH_2(C_{14}H_{11}O_4)_2$] is obtained by allowing formaldehyde to act on cotoin, and occurs in yellow, tasteless crystals or powder having a cinnamon-like odor. It melts at 211°–213° C. (412°–415° F.), is insoluble in water, soluble with difficulty in alcohol, ether, and benzol, and readily soluble in chloroform, acetone, glacial acetic acid, and alkalies. Overlach reports thirty cases of diarrhœa in which it was used in dose of 0.25 gm. (gr. iv.) three times a day as an intestinal astringent. He believes it preferable in cases with sloughs of the mucous membrane of the intestine, as, unlike the tannin preparations, it stimulates tissue growth and causes regeneration of the mucous membrane. Its advantages over cotoin are that it is free from pungent taste and is a more powerful bactericide. *W. A. Bastedo.*

FOUNTAIN PARK MAGNETIC SPRINGS.—Champaign County, Ohio.

Post-Office.—Fountain Park. Hotel and cottages.

Access.—Viâ Pennsylvania Railroad (P., C., C. and St. L., Indianapolis Division). The hotel is within five minutes' drive of the Fountain Park Station. The location is 34 miles west of Columbus and 12 miles east of Urbana. Fountain Park village was laid out in 1882 soon after the discovery of the springs. The resort came under the present management in 1894. The site of the village is one of great natural attractiveness. The elevation is 1,200 feet above the sea-level and the surrounding country is gently undulating. The hotel and cottages are located in a beautiful tract of 43 acres in which are numerous hills surmounted by groves of deciduous trees. New acme stone walks and driveways have recently been laid around the hotel grounds, and an artificial lake of sufficient size for boating constructed. The large lawn is adapted for all kinds of outdoor sports and games. Brush Lake, one mile east of the Park, affords rare attractions to the piscatorially inclined visitor. The waters at Fountain Park proceed from five flowing wells. The largest is 2,200 feet in depth and fills a ten-inch pipe at about twenty-one pounds' pressure. Following is an analysis of this spring, made in 1892 by Prof. E. S. Wayne, of Cincinnati:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	13.64
Calcium chloride	4.22
Magnesium chloride	2.12
Potassium sulphate	2.61
Calcium carbonate	20.24
Magnesium carbonate	11.41
Iron carbonate	.16
Silica	.24
Organic matter	.39
Total	61.03

This is an excellent water of the alkaline-saline-calcic variety. The presence of a small quantity of carbonate of iron will prevent debilitating effects on continuous use. The water has been found valuable in acute and chronic rheumatism, gout, dyspepsia, and diabetes. Two of the remaining four wells were analyzed in 1895 by Prof. H. A. Weber of the Ohio State University. They show the same general characteristics as Spring No. 1 (above). There is an excellent modern hotel in the Park. It contains twenty well-equipped bath-rooms, under the charge of an experienced physician. *James K. Crook.*

FOXGLOVE. See *Digitalis.*

FRACTURES.—A fracture is the breaking of a bone or of a cartilage. The sudden forcible destruction of the continuity of a bone in whole or in part, except when done with a cutting instrument, is called a fracture (Stimson). The gradual undermining of the strength of a bone, whether by tumor or by inflammation, does not produce a fracture until a trauma, however slight, snaps the diseased bone. The so-called *pathological* fractures are of this class. The trauma may be so slight as to pass unrecognized, but, nevertheless, this "sudden, forcible destruction of continuity" constitutes the fracture. The only etiological difference between pathological and traumatic fractures is that in the former the disease of the bone predisposes it to fracture and the violence required to produce the fracture is comparatively insignificant.

Varieties.—Fractures are commonly classified as complete and incomplete.

A Complete Fracture is a break traversing the whole thickness of a bone. In a long bone, this implies that the extremities of the bone are separated by the line of fracture. In a flat bone a complete fracture may simply break off a fragment.

Incomplete Fractures may be: (1) Fissured; (2) "Greenstick"; (3) Depressed; (4) Separation of a splinter or of an apophysis.

By a "depressed" fracture is here meant a depression of only part of the thickness of a flat or long bone. It is not an uncommon fracture of the cranial bones.

The commonest of all incomplete fractures is the *green-*