2. "Forcible passive motion, with or without anæsthesia, is always harmful before the second month, and even after that time it is far more likely to do harm than good. . . . The proceeding should, I think, be almost wholly abandoned, and in its place we should resort to massage, constant use within existing limits, and possibly to the recently introduced method of prolonged exposure to high, dry temperatures; and these failing, I should prefer to expose the joint by incision in order to remove such intra-articular obstacles as might exist and be removable rather than blindly to seek to break and tear them without knowing what and where they are."

Since the fingers are peculiarly liable to stiffening, especially if kept extended, they should always be immobilized in the position of flexion, and passive or active motion should be begun on them within the first two weeks.

Massage.—Massage at the hands of any one but an expert should never be employed until after union has taken place. Lucas Championnière is the ardent advocate of massage and passive motion in the early days. When employed with the utmost gentleness and skill these measures eliminate joint stiffness and hasten the resorption of the primary exudate and perhaps the union of the bone. But the treatment is expensive and therefore beyond the reach of most patients. Moreover, the benefit derived from it is in many cases a negligible quantity, while any mishap or excess of zeal on the part of the operator is not unlikely to delay union rather than to hasten it. Hence this treatment should be reserved for those cases in which the primary reaction is unduly prolonged or the joints are threatened.

When employed, massage should be given daily and very gently. Elastic pressure by a light rubber bandage is often equally useful. It is usually better to apply the bandage only by day.

Hot Air.—Treatment of recent fractures by dry air at a temperature between 300° and 400° F. has been advocated. The indications for its use are the same as those for massage. I have tried it only twice and in both cases it failed, though massage subsequently succeeded.

Ambulatory Treatment.—The vogue of the so-called "ambulatory treatment" is already waning. The idea is an extension of Lucas Championnière's theory that exercise is good for fractures and rest bad. Hence, it was urged, all persons suffering from fracture should be up and about at the earliest possible moment, and this may be accomplished for persons with broken legs by so strengthening the splint that the limb may be used in walking, the weight of the body being transmitted by the splint instead of by the broken bones.

It is a matter of common experience that a Pott's fracture is sometimes no more disabling than a sprained ankle, and that after the permanent splint has been applied, it may be possible to force the patient to walk with the aid of crutches, so little inconvenience does the injured ankle cause him. In such cases ambulatory treatment is quite appropriate, but the application of this theory to fractures of the femur or the tibia and fibula is entirely unwarranted and extremely dangerous. If there is danger of faulty or delayed union from gentle massage at the hands of a competent operator, this danger is multiplied a hundredfold for a patient thus turned out to take care of himself. Moreover, the alleged advantages of rapid union and ability to work are not proven. The safest form of ambulatory splint is a hip splint such as is employed for tuberculous disease, with a plaster encasement for the fracture. For fracture of the leg a very heavy plaster encasement is sometimes employed in which two stout lateral rods of iron or wood are incorporated, bearing above upon a band of plaster under the tuberosities of the tibia and terminating below in a cross-piece two inches below the sole of the foot. This splint transmits the body weight from the tuberosities through the splint to the ground. Though clumsy it is safe for a Pott's fracture but dangerous for a fracture of the leg.

Ambulatory splints should never be applied until after the subsidence of the primary swelling.

Direct Fixation.—Like the other accessory measures, direct fixation has been paraded as the only treatment for fractures. Yet though incision and manual reposition of the displaced bones would give theoretically perfect results, and lessen the primary œdema by allowing evacuation of the clots, the eminently satisfactory results obtained by the ordinary treatment as well as the danger of infection leave but few supporters to this theory.

The accepted indications for direct fixation are:

1. When incision is necessary for reduction, to remove comminuted fragments, or in certain special fractures (patella) to maintain apposition.
2. For most compound fractures.
3. For delayed union after milder means have failed.

The methods of applying direct fixation are two:

1. Periosteal suture.
2. Fixation of the bones themselves.

Suture of the periosteum and adjacent soft tissues gives but an indirect support to the bone. It can prevent only separation of the ends. Angular deviation and overriding must be prevented by splints.

Fixation of the bone is commonly accomplished by silver wire, nails, bone pegs, or special clamps riveted about the bone. These methods effect admirable apposition, but they have a common defect, viz., the liability of these wires, pegs, or clamps to act as irritating foreign bodies, causing bone softening either immediately about them or extending through the whole width of the bone ends and resulting in a fibrous union. This unfortunate result attends a large proportion of cases treated in this manner.

If, therefore, direct fixation is employed, periosteal suture is to be preferred, and if this does not effect sufficiently firm apposition, the bones should be united by a removable suture of silver or silk or some such apparatus as the Parkhill clamp* to be detached at the end of ten days or as soon as the provisional callus has been thrown out.

III. *Compound and Gunshot Fractures.*—The treatment of compound fractures may be broadly classified thus:

1. Treatment of "primary" or "direct" compound fractures in which the wound is gaping, contused, and infected.
2. Treatment of "secondary" or "indirect" compound fractures in which the wound is small, clean, and negligible.

The basis for this distinction has been noted above.

1. The treatment of direct compound fractures comprises extensive incision, copious irrigation with mild solutions, the trimming away and removal of all contused and befouled tissue, and all loose chips that are not firmly attached to the periosteum.

The periosteum and fascia are loosely sutured and gauze or gutta-percha tissue drains are inserted down to the bone, and antiseptic dressings applied.

The splint should be applied to the limb before the patient leaves the operating table. If the wound is expected to run a clean course a fenestrated plaster encasement is the best, reinforced if necessary by iron bands. If, however, suppuration is feared and daily dressings are

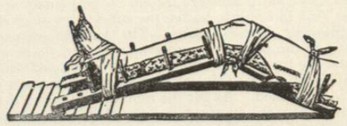

FIG. 2214.—Esmarch's Double-Inclined Plane.

expected, such a splint soon becomes soiled and soaked with the discharge from the wound in spite of every precaution. Removable splints, such as moulded splints, Volkmann's splint, the double inclined plane (Fig. 2214),

* Annals of Surgery, 1898, xxvii., 553.

Hodgen's (Fig. 2221) or Smith's splints (Fig. 2215) are then to be preferred. The latter splints afford elevation as well as immobilization.

The treatment of the wound is of the greatest importance. While the primary irrigation and antisepsis are chiefly to be depended upon to prevent infection, the irritation as well as the danger of infection from frequent change of dressings is a common cause of late suppuration. If the wound is but loosely sutured and lightly packed in the first place, it may sometimes be left undisturbed until the fourth day. If at the first dressing the wound is clean it should be disturbed as little as possible. Some of the drainage may be removed. The wound should not be irrigated. After this the drainage is renewed at intervals of from forty-eight to seventy-two hours until the wound is healed. If active suppuration occurs it must be combated by the usual antiseptic methods.

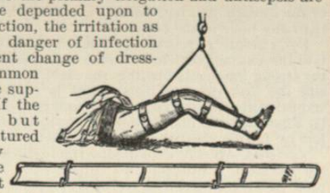

FIG. 2215.—Nathan R. Smith's Anterior Splint.

Amputation is rarely indicated at the time of accident. However crushed the limb may be, every attempt should be made to save it. If, however, the lower segment of the limb remains pulseless and incision into it produces only a stagnant venous ooze, it may be wiser to amputate rather than to subject the patient to a second operation. The rule in amputating is to save as much tissue as possible, and to this end it may even be wise, in case the surgeon feels confident of his asepsis, to allow the line of amputation to coincide in great part with that of the laceration.

2. When the wound is small and clean it may be treated by a superficial cleansing and precautionary drainage, or it may require operation as described above, at the surgeon's discretion.

Gunshot Fractures.—Fractures caused by bullets may be widely compounded or practically simple fractures. The special indications for treatment are dealt with elsewhere (see *Gunshot wounds*).

IV. *Articular Fractures.*—Most of the classical fractures involving joints, such as fractures of the anatomical neck of the humerus, fractures of the patella, Pott's fracture, etc., are to be treated by certain well-defined, special methods. But there are many unusual fractures involving joints, often caused by a direct crushing injury. They have few common features, and each must be dealt with individually. For the treatment of such fractures a few general rules may be laid down.

1. If the fracture is compounded, the joint should be fully cleansed of all foreign matter, fragments of bone, blood clots, etc., and copiously irrigated. Then, if there is a chance of avoiding infection, the joint should be sealed by suturing the soft tissues closely about it. If suppuration is anticipated continuous irrigation should be established and maintained for forty-eight hours. If suppuration appears in a case in which it had not been looked for, the joint must be opened and irrigated continuously until the infection is conquered.

2. Simple articular fractures usually require no special treatment except early passive motion to prevent ankylosis. Exceptionally operation may be undertaken to reconstruct a thoroughly disorganized joint, or to extract a fragment that defies reduction and threatens the future efficiency of the joint.

V. *Treatment of Complications.*—The early complications that require special treatment are (1) gangrene, (2) injury to a nerve, and (3) suppuration and sepsis. Among the later ones (1) persistent pain or paralysis, (2) joint stiffness, (3) delayed union, and (4) mal-union deserve mention.

Gangrene: Gangrene of the limb may often be averted by multiple longitudinal incisions through the skin and fascia (made under primary anæsthesia) followed by elevation and hot wet dressings. If these means fail (as they may do unexpectedly, since under an unbroken skin the deeper tissues may be reduced to a pulp by a crushing force) amputation should be resorted to at once. The line of amputation may be estimated by producing artificial ischæmia with the Esmarch bandage (to be used only if there is no infection). Whatever tissue reassumes a pink hue after the pressure is removed may be saved. If, however, the gangrene is progressive and septic, rapid amputation well above the gangrenous region should be performed immediately.

Injury to a Nerve: It should never be too hastily assumed that a nerve has been ruptured. The injury is a rare one, while traumatic paralysis, hysterical in nature or because the nerve has been bruised, is common and transitory. Moreover, no harm can come from waiting. Operation should therefore be delayed at least a week or two, at the end of which time, if there is no diminution of paralysis or anæsthesia, the rupture of a nerve may be considered probable and the nerve cut down upon and sutured. (See under Fractures of the Lower Extremity of the Humerus.)

Severe and persistent neuralgia may indicate pressure by a fragment or by the callus. To relieve it an incision is necessary, and if no such physical cause for the neuralgia is found, stretching the nerve may relieve the pain.

Suppuration and Sepsis: These complications are confined to compound fractures. To treat them judiciously may tax the keenest surgical instinct, for in many cases the suppuration is at first slight and the constitutional disturbance insignificant. To leave the wound unirrigated is to invite extension of the infection throughout the lacerated tissues, while to irrigate freely is to break down fibrinous adhesions, to bruise granulations, and to irritate the whole area to such an extent as enormously to encourage infection. To steer between the two is less a matter of intelligence than of instinct derived from experience. If the infection promises to be slight, and occurs later than the fourth or fifth day when healing has already progressed so far as to afford a barrier to the spread of suppuration, the pus may simply be mopped away and the cavity swabbed out with peroxide of hydrogen and packed with bichloride gauze (1 to 2,000) or one of the newer organic silver salts. If, however, the infection occurs early or presents other grave features, there is nothing for it but to irrigate the wound copiously (one to two quarts of bichloride solution 1 to 10,000) once and thereafter to change the dressings frequently in the hope that the infection may thus be repressed or at least confined to one spot.

The milder infections may be conquered by these local measures. The more virulent processes require wet dressings, antiseptic baths, multiple incisions, continuous irrigation or even amputations. As already stated, the union of the bone is delayed by the infection as well as by the manipulations, but I have known union to take place in the femur in two cases after a year of hospital treatment. Such a result could not be expected in an old man. He would not survive the prolonged suppuration.

Persistent Pain or Paralysis: There is always a good deal of stiffness and weakness for the first weeks after the patient gets about, but as long as his symptoms are lessening they require no treatment. Progress may be encouraged by any form of muscular or circulatory stimulation such as massage, exercise, passive motion, hot air, electricity, strychnine and other tonics. The salicylic-acid derivatives and colchicine may help.

Pains amounting in severity to an actual neuralgia and persistent paralysis are often best treated by operative investigation of the nerves.

Joint Stiffness: If this does not react to the treatment mentioned above, operation is the only resource.

Fingers that have remained immobile in the extended position for more than two months are practically beyond hope.

Delayed Union: This condition may be treated systemically by tonics, locally by irritants, or by operation. If the delayed union is due to systemic disease, such as syphilis, malaria, etc., this etiological condition must be combated. Over and above this it is customary to administer phosphorus or phosphate of lime. Thyroid extract has been recently employed. It has proved useful at the hands of some and has failed with others.

The local irritative measures may be employed in connection with the drugs or after they have failed. Painting with iodine or guaiacol and cauterization are of little benefit. Exercise is especially useful to encourage union of the tibia, when there is not too much separation. The leg is encased in plaster and the patient is instructed to walk upon it daily. Massage may help. If these measures fail congestion may be produced by bandaging the limb tightly above the fracture. The bandage is applied for two or three hours at a time, on alternate days, for a week. A more efficient and more painful treatment is the injection of a few drops of chloride of zinc (ten per cent.), tincture of iodine or alcohol into the band of union. This sets up an acute reaction which may be followed by ossification. Electrolysis is said to have the same effect. Still greater irritation may be produced by violently wrenching the limb about while the patient is anæsthetized.

Schaffer has obtained union in old fractures of the neck of the femur by special braces exerting direct pressure over the trochanter.

Operation is necessary when the above means fail, or when union is mechanically impossible on account of separation of the bone ends by the interposition of other tissues, or when they (tibia, ulna) are held apart by a parallel bone.

There are various methods of operating. The bone may be cut down upon, the band of union cut away, and the bone ends approximated by periosteal suture or bone pegs or wire. Parkhill's clamp seems especially fitted for this sort of work, and it has given good results after other methods have failed. Permanent wiring, pegging, or clamping is dangerous, for the reasons already stated (p. 256).

The presence of an actual new joint makes no material difference in the operative technique.

The prospect of success from any of these methods is none too glowing. The causes of failure of union may continue in force, and the difficulty in obtaining and maintaining the necessary approximation of the two fragments is great. All else failing amputation may be resorted to.

VII. *Mal-Union.*—When once a bone has united with deformity, the disfigurement can be remedied only by osteoclasis or osteotomy. Before suggesting such treatment, however, the surgeon will do well to consider whether with the material at hand, viz., the existing bony tissue, he can obtain a material improvement from any operation.

Fractures of the lower extremity of the humerus and Pott's fracture often call for relief, in the one case to overcome the restricted mobility of the elbow joint, in the other to remedy the deformity. In either case the best plan of treatment is to chisel through the bones along the old lines of fracture, to remove superfluous callus and then to reduce and splint the fracture as though it were a fresh one. This is done in the foot through curved internal and external incisions. In the elbow it may be impossible to ascertain the nature of the fracture or to be sure of what is callus and what is fragment. If such be the case the surgeon should rest satisfied with the removal of such bony protuberances as interfere with motion and the breaking up of adhesions. Passive motion should be begun at the end of a week and practised daily in order to prevent recurrence of the ankylosis.

SPECIAL FRACTURES.

Fractures of the Skull—See *Head, Injuries of.*
Fractures of the Spine—See *Spine, Surgery of the.*
Fractures of the Bones of the Face—See *Jaws, Injuries of;* and *Nose, Injuries of.*
Fractures of the Laryngeal Cartilages—See *Larynx, Fractures and Dislocations of.*

Fractures of the Clavicle.—Excepting the bones of the forearm and leg, the clavicle is broken more often than any bone in the body.

For clinical purposes the bone is divided arbitrarily into three equal portions. To the inner third are attached the strong ligaments binding the clavicle to the sternum and the first rib; the outer third is protected by the trapezius and the deltoid muscles and the coraco-clavicular ligament; the middle third is unprotected and it suffers by far the greatest number of fractures.

Varieties.—But five compound fractures of the clavicle are recorded. Multiple and comminuted fractures are rare. I have obtained an excellent result by removing a small fragment.

Incomplete fractures are insisted upon by Hamilton and Platt. The former reports 34 incomplete fractures in a series of 157 cases; the latter 25 in 115. The injury is unimportant. It is caused by a fall upon the shoulder in a young person. Within a few days after the fall a swelling appears about the middle third of the bone. False motion and crepitus may sometimes be elicited. No treatment is necessary, except perhaps a broad sling to elevate the elbow.

Simple fracture of the middle third may be transverse (children) or oblique (adults); the shoulder, losing its support, sinks downward and inward. The inner fragment lies above or in front of the outer. When the line of fracture is transverse there may be angular displacement or none at all.

Fracture of the outer third is rare. It is usually caused by direct violence. There may be no displacement and the fracture may pass unrecognized (Lane). Displacement when present is usually angular. If the fracture is within the outer inch of the bone the apex of the angle is upward, otherwise it is usually backward. Fracture of the inner third is very rare. Displacement is slight or absent.

Fracture of both clavicles is unusual. It has been known to cause considerable dyspnœa on account of the weight of the upper extremities upon the chest.

Etiology.—While fracture of the clavicle is usually caused by a fall upon the shoulder or the outstretched arm, it may be due to direct violence or even to such muscular efforts as striking a blow or lifting a heavy weight.

Symptoms and Course.—In fracture of the middle third crepitus cannot always be obtained, but the drooping shoulder and the shortening and deformity of the bone as compared with its fellow are characteristic. Flexion and extension of the arm may be but little impaired, yet abduction is quite impossible.

Fractures of the inner and outer thirds and all incomplete fractures can be diagnosed only by palpation along the bone.

The course of the injury is usually simple, though such complications as puncture of the subclavian vein, aneurism from injury to the artery, rupture of the brachial plexus, and emphysema from puncture of the lung, have been reported. Union may be expected at the end of the fourth week. As a rule, some displacement and shortening persist.

Treatment.—The method of reduction and immobilization is the same for all the varieties, except certain fractures of the outer third which require direct pressure by means of a strip of adhesive plaster passed over the point of fracture and the point of the elbow and back over the fracture (Stimson's dressing for dislocation of the outer end of the clavicle), and a simple sling. In all other cases the object aimed at is to remove the weight of the upper extremity, which drags the outer fragment downward, forward, and inward. To effect reduction, the simplest method is to lay the patient upon his back, manipulating the shoulder until the bone resumes its normal direction. This is simple: but to retain the bone

in place is a far more difficult matter; witness the infinite number of methods employed.

The treatment employed depends upon the result desired, whether a useful limb merely or a beautiful neck. To attain the former result a simple sling often suffices, while the latter may perhaps not be reached by the surgeon's most ingenious devices. In general, if a perfect result is desired, the patient must be kept on *her* back for three weeks in the most suitable of the dressings to be described below.

The dressings usually employed are Mayor's scarf, Velpeau's bandage, Sayre's dressing, and Moore's bandage. In applying these several thicknesses of towel or non-absorbent cotton (carded lamb's wool is better) should be padded into the axilla and between the limb and the side.

Mayor's scarf is made of a square of stuff, the diagonal of which is long enough to reach around the body. It is applied like an ordinary sling, but the lower ends are passed around the body and knotted in the back. This is a very satisfactory appliance for dispensary practice.

Fig. 2216.—Velpeau's Bandage.

Velpeau's bandage (Fig. 2216) is applied with the hand of the injured side placed on the opposite shoulder, "and the limb is drawn snugly up toward the neck by successive turns of the roller, which, beginning at the opposite axilla, pass obliquely across the back, over the shoulder, in front of the arm, under the elbow, and back to the axilla; after three or four such turns have been placed the bandage is carried circularly around the body, covering in the arm from below upward. The turns should be secured by stitching or by soaking in plaster."

Sayre's Dressing (Figs. 2217 and 2218) consists of "two strips of adhesive plaster, each about three inches wide, and long enough to go once and a half around the body; one end of the first strap is stitched loosely about the arm just below the axilla, and the other end carried around the back and the opposite side to the chest in front. The second strap is then carried from the top of the shoulder on the uninjured side across the back, under the elbow, and along the forearm to the shoulder again. The elbow should be drawn back while the first strap is applied, and well forward while the second is."

Of the latter two dressings Sayre's is the more efficient and lasting but the less comfortable. In each the hand should be left exposed.

Moore's bandage is made of a wide muslin bandage or scarf about two yards long. "Its centre is placed under the olecranon, the forearm being flexed at a right angle, the end that is next the body is carried up between the arm and the side, in front of and over the shoulder across the back and under the opposite axilla, the other end is carried around the outer side and front of the elbow, then between it and the side to the back and across the back to the opposite shoulder, where it is made fast to the first end. The elbow is drawn backward and pressed upward." The wrist is supported by a sling.

Various other splints are employed, too numerous to mention.

Fractures of the Scapula.—Fractures of the scapula are classified as: (1) fractures of the body; (2) of the inferior angle; (3) of the upper angle and supraspinous fossa; (4) of the spine; (5) of the acromion; (6) of the coracoid process; (7) through the surgical neck; (8) of the glenoid cavity.

Fig. 2217.—Sayre's Dressing for Fractured Clavicle. First strap.

Fractures of the Body, Lower Angle and Upper Angle.—These fractures are caused by direct violence or muscular action. The lower angle may be displaced forward and upward. Otherwise the displacement is insignificant. There are localized tenderness and swelling, and false motion and crepitus may perhaps be obtained. Fracture of either angle is extremely rare.

The arm may be put in a sling and the scapula immobilized by broad bands of adhesive plaster encircling the chest.

The Spine of the Scapula is fractured by direct violence. False motion and crepitus may be elicited. The arm should be kept in a sling.

Fracture of the Acromion is usually caused by a fall on the shoulder. Either the whole process or merely its tip is broken off. Epiphyseal separation is not uncommon. The contusion often obscures the signs of fracture during the first days, but later the displacement outward and downward may be felt. If the whole process is broken off the shoulder droops. Crepitus may sometimes be obtained by elevation or abduction of the arm. Spontaneous motions of the arm, especially abduction, are restricted. Bony union is not to be expected.

The treatment is that of fracture of the outer third of the clavicle.

Fracture of the Coracoid Process is a pathological curiosity. It usually occurs in connection with dislocation of the shoulder or other fractures. The symptoms are obscure, the diagnosis is difficult, reduction impossible, and the prognosis good.

Fig. 2218.—Sayre's Dressing. First and second straps.

Fractures of the Neck of the Scapula (including all those that separate the glenoid cavity from the body of the bone) are caused in the same way as dislocation of the shoulder, which they resemble closely. The glenoid process slips downward with the humerus and the long head of the triceps attached. The displacement is limited by the spino-glenoid and coraco-clavicular ligaments and the tension of the soft parts over the shoulder.

The symptoms are those of dislocation of the shoulder, from which the fracture is differentiated by the fact that elevation of the arm produces crepitus and obliterates the deformity, which recurs as soon as the pressure is re-

moved. The treatment is by Stimson's dressing for dislocation of the outer end of the clavicle (*q. v.*). Bony union with some displacement may be expected.

The Rim of the Glenoid Cavity is sometimes broken by dislocation of the shoulder.

FRACTURES OF THE HUMERUS.—Fractures of the humerus are classified as fractures of the upper extremity, fractures of the shaft, and fractures of the lower extremity.

Fractures of the Upper Extremity.—This title includes fissures of the head of the bone, a condition with no clinical significance, and avulsion of the greater or lesser tuberosity, usually a complication of dislocation, recognized by localized tenderness and crepitus, and treated by immobilization (after reducing the dislocation) in outward or inward rotation, according to the tuberosity involved. More important fractures are (1) fracture of the anatomical neck, (2) fracture of the surgical neck, (3) separation of the epiphysis, and (4) fracture dislocation.

True Fracture of the Anatomical Neck is extremely uncommon. The line of fracture usually runs along the anatomical neck and partly through one or both tuberosities. Unless a tuberosity is separated from the shaft, or the head dislocated, the diagnosis is usually impossible, and when a tuberosity is separated the fracture is often a high one of the surgical neck. Strict accuracy of diagnosis, however, may be aided by the *x*-rays in the future. The subjective symptoms vary from slight pain to complete disability. The periosteum is usually in greater part untorn and the displacement slight, though it may simulate dislocation. Crepitus may usually be obtained and the tuberosity may not partake in rotation imparted to the shaft of the bone. Exuberant callus with ossification of the capsule of the joint may result, or there may be non-union.

The treatment is simple immobilization with traction if there is a tendency to shortening. If suppuration should complicate failure of union, incision, removal of the fragment, and free drainage would be necessary.

Fracture of the Surgical Neck is the commonest fracture of the upper end of the humerus. This includes all fractures below the epiphyseal line. The lesion is usually caused by a fall on the shoulder or elbow causing a compression or torsion. Hence the line of fracture is irregular and comminution is not rare. There may be impaction. The upper fragment is usually flexed, abducted, and rotated outward, the lower one slightly displaced inward.

Function is completely lost; there is much local swelling and the elbow is usually abducted simulating dislocation; but the head is in place, and there is local tenderness along the line of fracture and tenderness when the elbow is pressed upward. Unless there is impaction rotation of the arm is not communicated to the trochanter.

If displacement and shortening are present reduction may be accomplished by traction in the line of the upper fragment, namely, abduction and slight flexion. The best retention dressing is a plaster band running along the inner side of the arm from axilla to elbow and with two tails at each end encircling the shoulder and forearm (Hennequin's splint), or an external moulded splint as for fracture of the shaft (Fig. 2210). The elbow is flexed and left unsupported. A narrow band slings the wrist. If displacement or shortening recurs it is overcome by splinting the arm in abduction over a triangular pad reaching from elbow to axilla, made by cracking a piece of cardboard, holding the two sides at an angle of some 30° to 40°, filling in with soft cloths or cotton, and sewing a cover over all. The pad is placed with its sharp angle in the axilla, its base at the elbow (*conf.* Scudder, "Fractures"). Counter-traction is obtained by suspending a five-pound weight at the elbow. If the patient is confined to his bed the weight is attached as for fractures of the thigh (*q. v.*). The tendency to displacement is overcome at the end of two weeks and union is firm at the end of five or six weeks.

Separation of the Epiphysis.—This lesion replaces high fractures of the surgical neck in the young. The epiphyseal line runs through the lower edge of the tuberosities and the epiphysis is hollowed out in its centre, capping the shaft, as it were. The periosteum is usually little torn, the shaft displaced forward and its posterior edge fitted into the cup of the epiphysis which is tilted back. The upper edge of the shaft can, therefore, usually be felt below and in front of the acromion. The head is in place. Function is lost. Upward pressure on the elbow is painful. There is tenderness at the point of fracture.

Reduction is accomplished by abduction and direct pressure upon the ends of the fragments. The subsequent treatment is that of fracture of the surgical neck. Union is prompt, yet premature ossification of the cartilage may lead to shortening of the arm. Surgery is called for if the untorn periosteum prevents reduction, or later if union has taken place with deformity and the range of motion is much impeded.

Fracture-Dislocation.—Dislocation of the head of the humerus is sometimes complicated by fracture of the anatomical or surgical neck of the bone (see *Dislocations*). The proper treatment is to endeavor to replace the bone by traction and manipulations with the patient anæsthetized and prepared for operation. If this fails the head of the bone should be cut down upon and replaced with the aid of McBurney's hook, or removed if replacement is impossible. The older methods of awaiting union before reduction or trying to obtain a false joint have proved eminently unsatisfactory.

Fractures of the Shaft.—Every variety of fracture of a long bone is met with in the humerus. Muscular effort not infrequently causes the fracture. The most notable complications are injury to the brachial vessels and the musculo-spiral nerve.

Reduction is effected by traction. Very high fractures may have to be treated as fractures of the surgical neck, low fractures as supracondylar fractures, contused or compound fractures by rest in bed with the arm supported on cushions until all danger of inflammatory complications has passed. The dressing I prefer is a moulded plaster-of-Paris splint from the side of the neck over the shoulder, down the outer and posterior aspect of the arm, under the elbow and forearm to just above the wrist or a similar gutta-percha splint (Fig. 2210). When this is applied the elbow must be padded an inch deep in cotton. On the second or third day the splint is removed, the greater part of the cotton extracted, and the splint replaced and held in place by adhesive plaster, over the shoulder, around the arm just above and below the point of fracture (thus leaving it open for inspection), on the arm and forearm close to the elbow, and lower down the forearm. The dressing is completed by a shoulder spica and a sling about the wrist, and an axillary triangle if necessary (see above). With the limb in this splint there should be enough traction to prevent overlapping or angular deformity. This traction is allowed by the removal of the cotton from under the elbow and maintained by the adhesive strips on the upper forearm. The patient should be seen twice a week for the first three weeks, and if at any time deformity has recurred it must be promptly overcome by suspending a five-pound weight from the elbow, by coaptation splints of basswood, or by renewing the splint with a greater allowance for elbow traction. The sling at the wrist must not support the splint lest it elevate the elbow. Union is firm at the end of six weeks.

Fractures of the Lower End.—These may be classified as supracondylar fracture, fracture of the internal epicondyle (there are only two recorded cases of fracture of the external epicondyle), fracture of the internal condyle, of the external condyle, intercondylar fractures, hypocondylar fractures, and epiphyseal separation. This confusing array is much simplified by a few general considerations of diagnosis and treatment.

Diagnosis.—To differentiate sprain, dislocation, and fracture about the elbow is a matter of physical examination. Evidence of abnormality in the bones themselves indicates fracture. Evidence of abnormality in the relation of the bones to one another indicates dislocation. Entire absence of these abnormalities indicates simple sprain.

Evidence of abnormality in the relation of the bones to one another is obtained by locating the tips of the two epicondyles, the olecranon, and the head of the radius. When the elbow is fully extended the three former should be in the same horizontal plane, and the head of the radius be recognized as a projection just below the external condyle. It is identified by the motion imparted to it by rotation of the forearm. If the relations of olecranon and radius with the epicondyles are not the same as in the normal elbow of the opposite side (with which comparison should always be made) there is dislocation, which may often be verified by an estimation of the abnormal axes of the bones.

Evidence of abnormality in the bone (*i.e.*, the humerus) is obtained in several ways: by eliciting false motion or crepitus between the condyles and the shaft or small fragments; by mapping out the general deformity of the arm as well as the local deformities about the elbow, the displacement of one or both condyles, and the irregularities along the supracondylar ridges; and finally by eliciting pain. If there is transverse fracture there will be pain on pressing the flexed elbow upward. A local point of pain can often be identified along one or both supracondyloid ridges where the fracture nears the surface, and if there is a line of fracture between the condyles, pressing the two condyles toward each other is painful.

Dislocation and fracture often coexist.

Thus the examination is begun by inspection to note any manifest deformity. An effort is then made to locate and determine the relations of the bony points mentioned above, and the range of motion, active and passive, tested with an eye to abnormal mobility, especially lateral mobility, and crepitus. The supracondylar ridges are searched for points of irregularity and tenderness, and pressure is made under the elbow and upon the two condyles to elicit tenderness. Suspected parts of the joint are then reviewed for false motion or crepitus.

The contusion is, however, often so excessive as to frustrate the surgeon's best efforts. Even an examination under ether may fail to elucidate the diagnosis. The *x* rays may then be appealed to. The evidence which they furnish should be definite.

Treatment.—Once the diagnosis is established reduction is not difficult. Rarely the fragment is so rotated as to make reduction impossible. Such fragments must be cut down upon and replaced or excised. Fragments of the epicondyles cannot often be retained in place. Their displacement is unimportant, however. Larger fragments acting rebelliously may be excised or sutured in place or nailed to the adjoining bone by a spike driven through the soft tissues and protruding through the dressings, to be removed within ten days.

With these exceptions reduction and retention are easily managed. The best position for the forearm is in all cases one of semiflexion with the natural pronation. The apparent security of complete flexion or extension does not compensate for the displacement which so often occurs with the elbow in these positions. For compound fractures, however, vertical suspension with the elbow extended is a convenient position during the first days, after which the limb may be brought down to the usual semiflexion.

The most convenient splint is a posterior moulded plaster band or wire gutter running the whole length of the arm and forearm and bent to a right angle at the elbow. If adhesive straps are used to retain the splint they should not cover the fragment (the position of which must be frequently verified). A five-pound weight hung from the elbow will overcome the tendency to displacement. The elbow is never to be supported. A sling about the wrist is sufficient.

If perfect reduction is not maintained, a cubitus varus or valgus may result which can be remedied only by osteotomy.

When union is firm and the arm is freed from its splint (at the end of five weeks) the elbow will be found sore and stiff. Motion and massage will help loosen up the joint, but an excessive zeal will only succeed in encouraging the growth of exuberant callus and so permanently restricting the range of motion. Such exuberant callus may also occur through no fault of the surgeon, but it is difficult to estimate its importance within six months. At the end of that time the joint will have gained its maximum of freedom, and the remaining restrictions caused by displaced fragments, ossified ligaments, callus projecting into the olecranon or coronoid fossæ or elsewhere into the joint can be removed only by the chisel. Yet it is well to be conservative in such operations. A mobility of from forty to fifty degrees at the elbow is about all that is needed as far as utility is concerned, and unless there is some definite projection of bone or callus the removal of which will clearly liberate the joint, an operation may well result in nothing more than disabling the patient for a few weeks, during which time new callus replaces that which was excised and after which the patient returns to his duties no better off than before. No general rules for operation can therefore be laid down. Each case must be decided on its own merits.

Of the numerous vessels and nerves in close relation to the joint, the ulnar nerve is the only one likely to be injured. Ulnar paralysis and anæsthesia have been known to disappear spontaneously as late as three months after injury, but in doubtful cases an early operation should do no harm and might do much good.

In *supracondylar fracture*, the lower fragment consists of both condyles and the whole lower extremity of the humerus. The line of fracture is oblique and the fragment slips upward and backward or upward and forward. The condition usually resembles a dislocation, but the relation of olecranon to condyle is unchanged and lateral mobility can be obtained with crepitus. Moreover the fracture when reduced has often a tendency to slip out of place again, with crepitus.

Fracture of an epicondyle is recognized by the abnormal mobility, displacement, and crepitation. Persistent displacement is unimportant since the line of fracture is entirely outside the joint.

In *fracture of the internal condyle* the line of fracture runs obliquely downward and outward from some point in the epicondylar ridge to the region between the trochlea and capitellum. The fragment with the ulna attached is usually displaced backward and the radius may be dislocated in the same direction. Abnormal adduction and antero-posterior sliding are possible. The ulnar nerve may be injured. There is a marked tendency to recurrence of the displacement with the production of cubitus varus. This may be overcome by immobilization with extension, with special care to preserve the normal outward angle at the elbow, by immobilization in flexion aided by a weight supported from the elbow, or by operative fixation.

Fracture of the external condyle is somewhat more frequent than the last mentioned. Its features are similar to those of fracture of the internal condyle, *mutatis mutandis*, but there is less liability to displacement. Indeed there may be a tendency to displacement downward, which would only be encouraged by suspending a weight from the elbow.

Intercondyloid fractures are caused by direct violence. The fracture is often compound or comminuted, its general lines being T- or Y-shaped, with the condyles separated from the shaft and from each other. The ulna may be jammed between the fragments. Reduction is important and may be difficult on account of the number and displacements of fragments. If reduction cannot be performed thoroughly under an anæsthetic, the bones had best be cut down upon and fastened in place or excised according to the judgment of the surgeon.

Separation of the epiphysis is rare. (Consult Plate XXVIII., Fig. 6.) The condition simulates backward dislocation, but the epicondyles retain their relation to the olecranon and the whole may be reduced (and re-

curs) with cartilaginous crepitus. The usual treatment is required.

Hypocondylar fractures, i.e., fractures of the articular processes, either one or both together, are extremely rare. They are caused by a severe crushing force applied beneath the elbow or transmitted up the forearm. When not associated with other injuries about the joint, they are to be recognized only by crepitus, the *x*-rays, or the displacement of a fragment to a place where it can be left.

Fractures of the Bones of the Forearm.—It is convenient to group the fractures of both bones of the forearm under three headings: fracture of the upper ends, fracture of the shafts, and fracture of the lower ends.

Fractures of the upper ends include fractures of the olecranon, of the coronoid, and of the head of the radius.

Fracture of the Olecranon (see Plate XXVIII., Fig. 8), though usually due to a fall on the elbow, is apparently caused by the violent contraction of the triceps (Stimson). The position and direction of the line of fracture vary widely. The displacement may be so slight that the chief evidences of fracture are independent mobility and crepitus, or so great that the gap between the olecranon and the shaft is readily felt. Yet practically the displacement is found to be slight in most cases. The tendency of the triceps tendon to carry the fragment upward is counterbalanced by the strain on the lateral fibrous attachments of that tendon.

Hence in a surprisingly large proportion of cases immobilization of the elbow in a position of slight flexion is quite compatible with good position of the fragments. The best splint is an anterior moulded one since it allows inspection of the fragment. Careful watching is necessary to forestall late displacement by the continued action of the triceps. To prevent displacement early or late it may be necessary to keep the elbow fully extended, to draw down the fragment by means of adhesive plaster strips, by Malgaigne's hooks, or by operation as for fracture of the patella, the suture being passed from side to side through the tendon and the ulna. If ankylosis, a rare complication, is feared, on account of the intensity of the inflammatory reaction, early passive motion (third week) may be employed. This treatment should, however, be conducted with extreme gentleness since it has been known to cause refracture.

Union is usually fibrous, sometimes bony, and may fail entirely. Unless motion is interfered with by adhesions within the joint, a satisfactory power of extension may be anticipated even though the separation of the fragments amounts to half an inch.

For non-union or undue separation of the fragments the bone may be cut down upon, the fibrous tissues excised, and the fragments sutured together.

Fracture of the Coronoid Process is usually a complication of backward dislocation of the elbow. It is rarely recognized and is unimportant. The separation is slight, for the fragment is held in place by the tendon of the brachialis anticus attached about and below it. This fracture may allow recurrence of the associated dislocation. The elbow must be immobilized in flexion for three weeks.

Fracture of the Head of the Radius is recognized by the localized tenderness, the discovery of a displaced fragment, pain in abduction of the forearm, and pain and crepitus on rotation. The absence of pain on adduction or on pressure of the two bones toward each other excludes fracture of the neck of the bone. The treatment is immobilization, removal of displaced fragments, or, if these fail, resection of the head of the bone.

Fractures of the Shaft of One or Both Bones.—These fractures are usually caused by direct violence. Green-stick fractures are commoner here than anywhere else in the body. Platt records 199 fractures of the shaft. Of these 122 were complete; 66 affected both bones; 42 the radius alone, and 14 the ulna alone. Of the 77 green-stick fractures, in 63 both bones were broken, the radius alone in 9, the ulna alone in 5. Instead of both bones breaking, the ulna alone may give way while the head of the radius is dislocated. When both bones are fractured the radial fracture is commonly nearer the elbow than the ulnar one. The usual displacements depend on the actions of the pronator and supinator muscles. The former tend to draw the fragments toward each other, and this is especially marked in short lower fragments acted upon solely by the pronator quadratus; the latter put the upper fragment of the radius (especially if the break is above the insertion of the pronator teres in the middle third of the bone) in supination (Plate XXVIII. Fig. 1). Overlapping also usually exists.

It is scarcely possible to mistake a fracture of both bones. When the ulna is broken the seat of fracture may be located by palpation. This is impossible along the radius, which lies surrounded by muscles for the greater part of its length; but when the radius is fractured forced pronation cannot be resisted and independent mobility and crepitus may be obtained by grasping the head of the bone firmly while the hand is gently rotated.

Reduction is of prime importance. It is accomplished by local manipulation and traction, direct when both bones are broken, toward the sound bone if only one has given way. It is especially important that the bones be crowded apart lest they unite to each other and thus effectually prevent rotation (Plate XXVIII. Fig. 7). This is accomplished by crowding the muscles between them and by the subsequent splinting. In the immobilization two important facts are to be borne in mind:

1. No circular dressing, bandage, nor splint may be applied close about the forearm. Such a dressing will force the fragments toward each other, or, worse still, it may cause gangrene or "ischæmic contracture" of the muscles of the forearm, from which they may never recover.

2. Whenever the radius is broken, unless in its lower third, it is safe to immobilize the forearm in supination. The routine attitude of semipronation usually leaves some rotary displacement between the radial fragments (as explained above) which, while it may not be enough to interfere materially with the function of the limb, still prevents complete supination. Moreover, the shafts of the bones are most widely separated in the position of supination and hence least likely to unite to each other.

The routine practice, therefore, of employing heavy wooden anterior and posterior splints (Figs. 2208, 2209) is most commendable. The splints run from the elbow to the knuckles. They are well padded and bound to the limb with strips of adhesive plaster, the boards being wide enough to prevent constriction. A small roller bandage elevates the palm of the hand from the anterior splint and the whole is encased in a roller bandage and supported by a sling with the hand supinated. A broad sling is employed reaching from elbow to hand. If the hand is not supinated care must be taken lest the sling, by supporting one end of the limb more than the other, cause an angular displacement or an approximation of the bones to each other.

If the limb is extensively contused or becomes markedly œdematous, it should be treated for a few days by elevation, hot wet dressings, and perhaps multiple incisions to prevent gangrene. This precaution may not be lightly disregarded since the muscles of the forearm may be reduced to a pulp, although the skin shows scarcely a sign of injury.

Fractures of the Lower Ends.—Platt tabulates 88 simple Colles' fractures, 7 with additional fracture of the lower end of the ulna, and but 2 fractures of the ulna only. Besides these he reports 6 cases of epiphyseal separation of both bones, 36 of the radius only, and 1 of the ulna alone. All of these varieties are clinically reducible to Colles' fracture. One other variety there is of fracture in this region, the so-called Barton and reversed Barton fractures. This condition is a splintering of the posterior or anterior edges of the under surface of the lower end of the radius by partial dislocation of the wrist backward or forward. The fracture is an insignificant complication of the dislocation and is rare.

Colles' Fracture.—"Every dislocation of the wrist is a Colles' fracture." As a statement this is false, but as

EXPLANATION OF
PLATE XXVIII.

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FIG. 1.—Fracture of the shaft of the radius above the insertion of the pronator teres, showing outward rotation of the upper fragment by the biceps and suggesting the necessity of splinting the forearm in full supination.

FIG. 2.—Longitudinal section of lower end of radius, showing old unreduced Colles' fracture.

FIG. 3.—Similar specimen, showing less displacement but more impaction.

FIG. 4.—Lateral displacement in Colles' fracture. Projection of the ulnar styloid process.

FIG. 5.—Diagrammatic representation of the bone lesion in Fig. 4.

FIG. 6.—Coronal section through the elbow joint, showing epiphyseal development of the capitellum, the internal epicondyle, and the head of the radius.

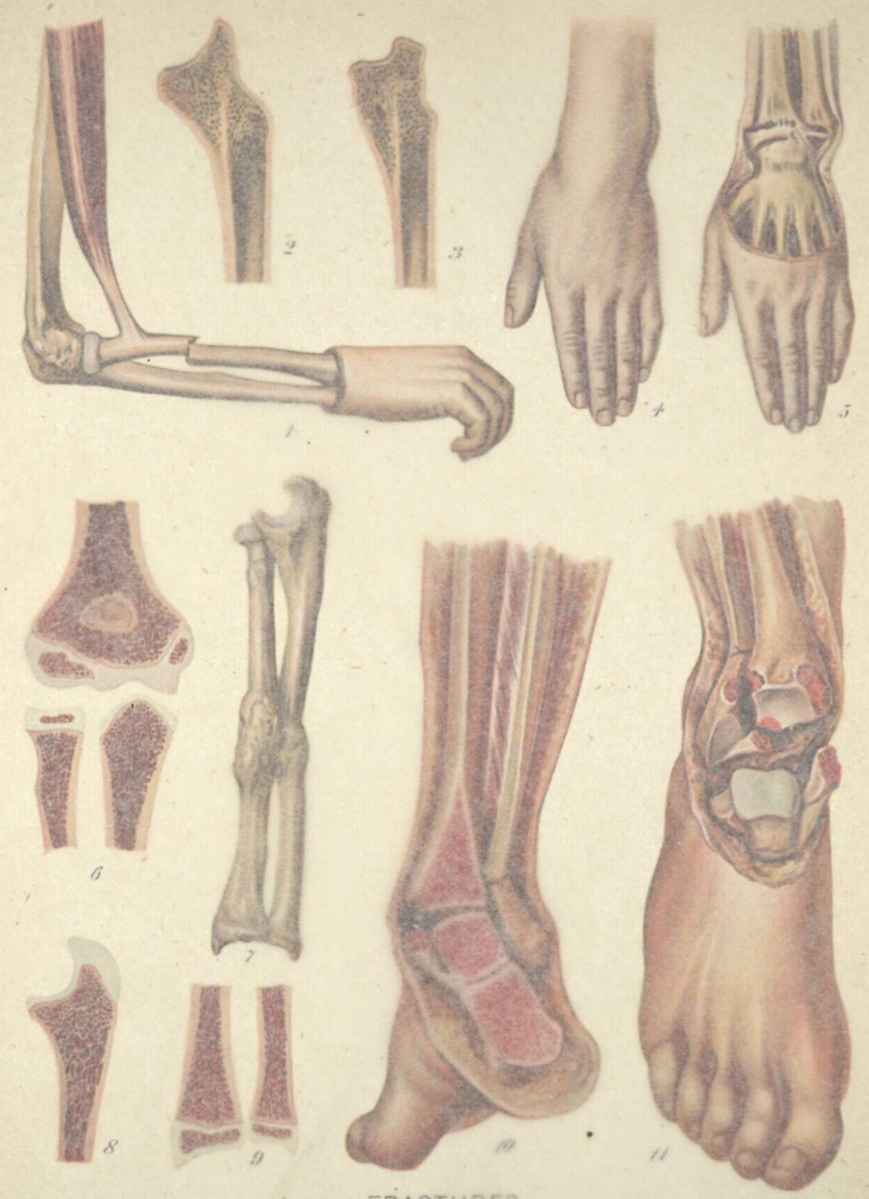
FIG. 7.—Old fracture of both bones of the forearm. The bones are united by exuberant callus.

FIG. 8.—Sagittal section of the ulna of a child, showing the epiphyseal cartilage in which the bony nucleus of the olecranon appears during the tenth year.

FIG. 9.—Coronal section, showing the epiphyses at the lower ends of the bones of the forearm.

FIG. 10.—Oblique section, showing tibial and fibular fractures and outward displacement in Pott's fracture.

FIG. 11.—Ankle joint laid open after Pott's fracture, showing points of fracture and tibio-fibular diastasis.



FRACTURES.

IMPORTANT ANATOMICAL AND PATHOLOGICAL FEATURES. (From Helferich's Atlas of Fractures and Dislocations.)

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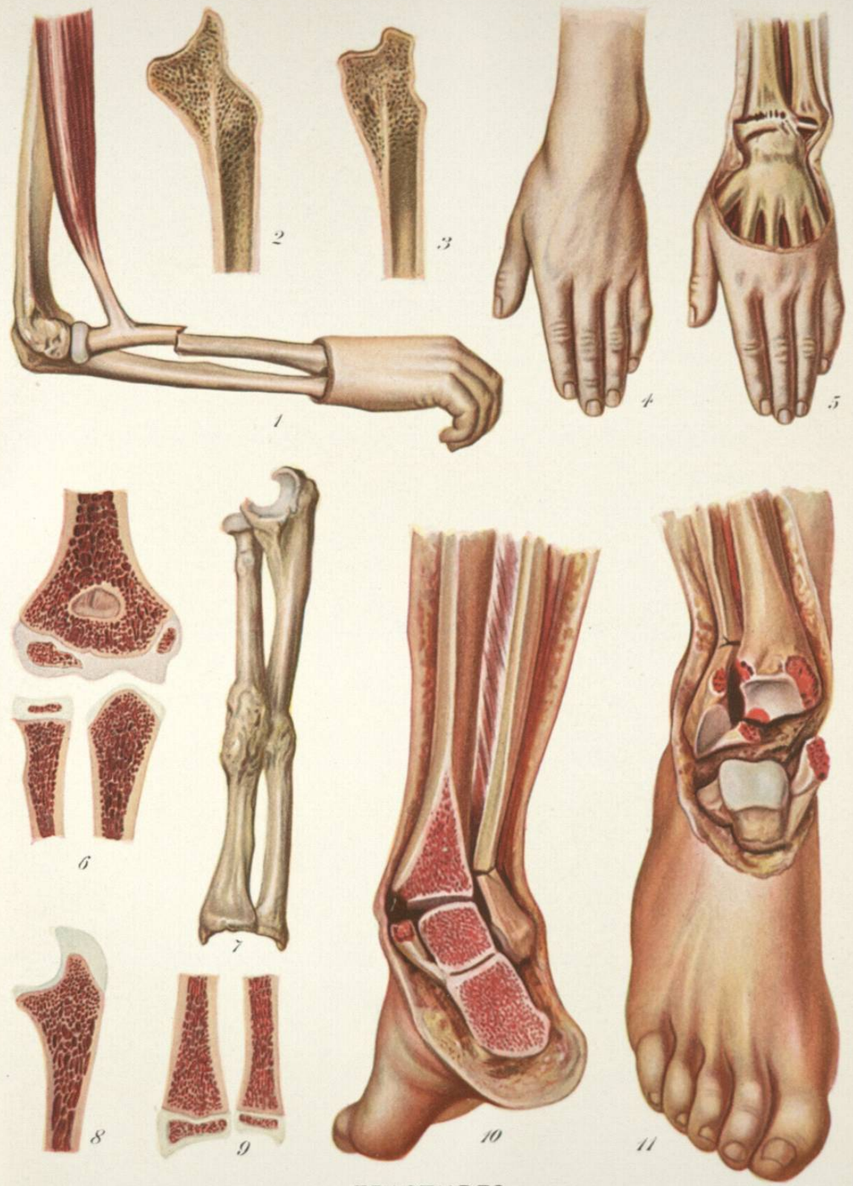

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