above, below, and at the circumference, is enlarged and irregular. It is this which forms the irregular enlarged ends so characteristic of the disease. The zone of hypertrophied cartilage cells as well as the columnar zone is enormously enlarged. There is also a more or less complete absence of the zone of calcification of the cartilaginous groundwork, and in addition there is a great irregularity in the formation of the vascular, medullary

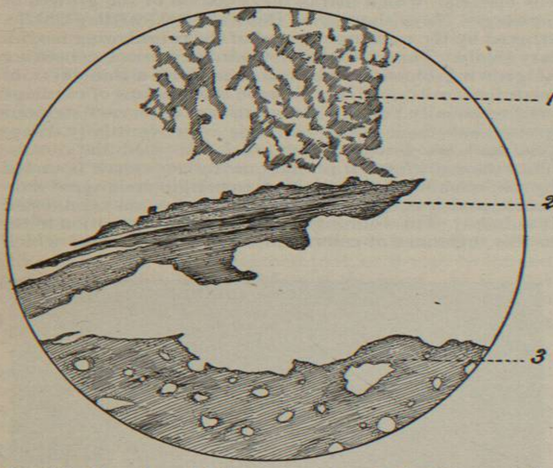

FIG. 649.—Necrosis and Inflammatory Hyperplasia of Bone. (After Boyce.) 1, Spongy new bone; 2, remains of shaft; 3, sequestrum. (Slight enlargement.)

canals. These have pushed their way into the cartilage in an irregular manner as though unrestrained by the presence of a firmly calcified groundwork.

The persisting columns of cartilage are gradually converted into an "osteoid" tissue, made up of cells derived from the medullary tissue and a fibrillar, uncalcified groundwork. This osteoid tissue will show in numerous places islands of persisting cartilage. The zone of osteoid tissue may attain a length of 15 mm.; it is a firm, elastic connective tissue, but it bends under pressure. It differs from bone in that the cells have not the same regularity of arrangement, and in the absence of earthy material in the groundwork.

At a varying distance below this zone we finally come upon a zone in which columns of osteoid tissue are becoming converted into bone by the calcification of the groundwork.

Inflammations of bone occur in the periosteum, in the marrow, or in the joints; that is, always in those portions of the bone which are well supplied with blood-vessels. They are as a rule due to hæmatogenous infection or to trauma, although occasionally they may be brought about by extension from neighboring tissue. If the inflammatory process is of any considerable degree, or lasts for a considerable time, it is always followed by changes in the bony substance itself. This, as a rule, is of a retrograde character, *i.e.*, leading to destruction of bone. If the inflammation is of a highly infectious, purulent character, the connective tissue affected becomes dissolved, the vessels become thrombosed and are destroyed, and the bone becomes necrotic. If the inflammation is less severe in character, if it is accompanied by considerable cell infiltration and the formation of new vessels (granulation tissue), there follows a gradual solution of the neighboring bone or cartilage, an ulceration, or, as it is usually called, caries. As long as this inflammation keeps up, so long is there a gradual absorption of the neighboring bone or cartilage. If in the beginning of the inflammation there occurs necrosis of a certain portion of bone, there follows in the later stages, at the surface of this necrosed portion, a gradual absorption which has its greatest intensity at the border between living and dead bone, so that eventually the two become separated and there is formed a sequestrum. If the latter is not very large it may in the course of time become completely absorbed by the neighboring granulation tissue. Large sequestra, however, offer a great deal of resistance to this absorptive process and may remain for years. As long as the sequestrum is present so long will the inflammation keep up, even though the infection has been overcome. A piece of dead bone acts as a foreign body and is a sufficient irritant to keep up this chronic form of inflammation.

In addition to this destructive process in bone accompanying inflammation, every such process lasting for any considerable time is accompanied by a hyperplasia, which manifests itself partly in the vascular soft parts and partly in the bone itself. This occurs both in the immediate neighborhood of the inflammation and in surrounding portions of the bone. It leads to those processes which have received the names of hyperostosis, exostosis, osteophytes, and parostosis. The most excessive hyperplasia of bone occurs in those cases in which a large sequestrum remains as a source of irritation for months and years.

Of acute infections, *osteomyelitis* is the most severe acute inflammation of bone with which we have to deal. It occurs most frequently in young individuals, as a rule in one of the long bones, and is accompanied by fever, by a destruction of more or less of the bone, and by the formation of an abscess. The infection is either primary or secondary to one of the acute infectious diseases. As a rule, the immediate cause is the staphylococcus pyogenes aureus or albus. The process may begin either in the periosteum, or in the marrow of the bone. It very soon leads to the formation of pus and to the destruction of bone. In severe cases it may lead to the suppuration of the marrow of the entire diaphysis and to an extension into the cortex of the bone through the Haversian canals. It may occasionally break through the periosteum. If the inflammatory process is near a joint, the pus may be poured into the cavity thereof. Through the formation of septic thrombi in the veins, we may have multiple metastatic abscesses and death by pyæmia. Wherever we have had a suppurative inflammation, there is of course a death of more or less bone, but the extent of this necrosis depends upon that of the suppurative process. If this has been very slight, the necrosed pieces of bone may become absorbed, so that they may not be discovered. In more severe forms we may have a sequestrum comprising the entire diaphysis. According to the extent and seat of the necrosis there may be distinguished a total, a partial, a central, and a superficial necrosis. Very soon after the setting in of the suppurative process there will be formed at the border, between the dead and the living parts, a zone of granulation tissue. This leads eventually to the separation of the sequestrum. When this has become complete there will be present, within the bone, an abscess cavity containing a sequestrum. This cavity very often connects with the surface of the bone by means of an opening or fistula. The walls of this fistula are also covered by a layer of granulation tissue from the surface of which pus is being poured out. In the neighborhood of these areas of granulation tissue there will have occurred more or less hyperplasia of bone which leads to a thickening. If the bone has been destroyed in its entire thickness in the beginning, then this hyperplasia occurs of course only in the periosteum, which thus surrounds the sequestrum with a firm, bony capsule. In cases of partial necrosis, however, new bone is formed both from the periosteum and in the interior of the bone. Small sequestra may in the course of months be absorbed; large ones constitute an irritant sufficient to maintain an inflammatory process for years, and they can be gotten rid of only by operative procedure. After the removal of the sequestrum the wound cavity is closed by means of granulation tissue, which later may be replaced by the formation of true bone through the activity of the periosteum or of the bone marrow.

Tuberculosis of bone gains entrance either through the marrow, the periosteum, the joint, or the surrounding soft parts. The most frequent method of development is that of a small tuberculous nodule which forms in the marrow of an epiphysis. This undergoes caseation and softening and eventually breaks through the bone to the surface, thus either entering into the joint or breaking through the periosteum. The process is of course always accompanied by caries, at times of considerable extent. A notable example of this is seen in tuberculosis of the spine, where the bodies of one or more vertebræ may be destroyed. This of course leads to the extensive deformities that we see in this disease (Pott's disease). After such a bone abscess (for this it really is) breaks through the periosteum, there are formed collections of pus in the surrounding tissues, particularly between the muscles. These sometimes reach an enormous size, and may through the influence of gravity dissect their way for a considerable distance through the body before reaching the surface.

In miliary tuberculosis, we have numerous tubercles in the bone marrow. Occasionally the tuberculous process affects the long bones of the hand or the foot in a very

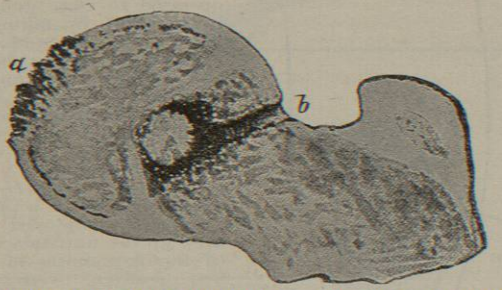

FIG. 650.—Severe Tuberculous Coxitis. The disease has broken through the cartilage at *a*. In the region of the neck is a sequestrum about the size of a cherry stone lying free in an abscess cavity connected with the joint by means of the fistula *b*. (After Krause.)

slow and chronic form, leading to resorption from the internal surface and apposition at the periosteal surface, and in this way producing certain peculiar spindle-shaped swellings that have been termed spinæ ventosæ. This may be followed by the occurrence of necrosis and the formation of sequestra and fistulæ, but in most instances the swelling eventually disappears.

Syphilis occurs in bone in three forms:

(1) Gummatous formations affecting both the periosteum and the marrow. In the periosteum, the process is accompanied by a destruction of bone, of such a character that sharply defined defects are produced—the so-called caries sicca. This occurs more especially on the calvarium. Occasionally one finds in the neighborhood of these bony defects new growth of bone.

(2) Hyperostosis. This occurs either in the form of hard, ivory-like thickenings in the compact bone, or in the formation of irregular exostoses or osteophytes. The latter form is found more especially in the tibia.

(3) Congenital syphilitic osteochondritis. This in its severe form is accompanied by the formation of irregular growths in the zone of growing bone, growths which have undergone a fatty and calcareous degeneration, and which may have the character of true gummata. In the lighter forms we have simply a calcification of the zone of cartilaginous hypertrophy at the epiphysis, marked by a sharp, yellowish-white line, and accompanied by a slight sclerosis of the neighboring bone. This affection is always present in congenital syphilis, but may disappear, so that a few weeks or months after birth it may not be found.

Actinomycosis of bone begins, as a rule, in the marrow by the formation of granulation tissue, which causes an absorption of bone from the inside and is accompanied by an apposition of bone on the periosteal side. In this way we may have large projections from the surface of the bone which, in decalcified and macerated preparations, will show on the inside the formation of a number of cysts. At times the actinomycotic process pushes through the bone to the periosteum, destroying this without being accompanied by the apposition of new bone, so that there will be produced a caries in the form of an osteoporosis.

Sarcomata are frequently found in bone. They occur either in the marrow (myelogenous sarcomata) or in the periosteum (periosteal sarcomata). Those that occur in the marrow of the bone produce, by the absorption of bone from the inside and apposition of bone from the outside, enlargements of the bone which attain at times enormous size, and in which we have the tumor mass surrounded by a more or less well-developed capsule of bone. Later on, even this capsule becomes either partially or totally destroyed by the pushing of the tumor through the bone. The tumor is as a rule of the round-celled variety, containing usually a large number of multinucleated giant cells. These giant cells may at times attain such enormous size as to be visible to the naked eye. Occasionally, however, they may be entirely absent. These sarcomata are exceedingly apt to recur after an excision or amputation. Periosteal sarcomata have, as a rule, a very considerable framework of bone in which the sarcomatous masses are enclosed, so that they are more aptly termed osteo-sarcomata. Occasionally also they have in addition a certain amount of cartilage, when they are called osteo-chondro-sarcomata. They are, as a rule, of the spindle- or small round-celled variety without giant cells. They are exceedingly apt to form metastases, especially in the lungs. *Simon Pendleton Kramer.*

BONE, PLASTIC SURGERY OF THE.—Defects in bone heal so slowly and imperfectly that it is no wonder surgeons of very early times tried to assist nature in their repair. There is some reason to suppose that such efforts were successful in India more than five hundred years ago, while a Peruvian skull antedating no one knows how long the discovery of America has, according to McGee, been found with a silver plate sunk in its substance to protect the opening made after trephining. The condition of the bone shows that the plate rested in it for a considerable time before death.

Despite this long history, and the very numerous experiments which have been carried out in recent years with the aid of a fuller knowledge of asepsis, the subject of repairing large defects in bone is still very imperfectly understood.

The indications for bone transplantation or some similar procedure are:

1. To afford a protection to underlying organs, notably to the brain after extensive removal of the cranium by accident or operation.

2. To preserve the normal contour of the parts—for instance, after loss of the bridge of the nose or half of the lower jaw.

3. To maintain the continuity of a bone so that the power of a limb shall not be lost.

4. To shorten the time of recovery, for a deep cavity in a bone—for example, in the head of the tibia—heals very slowly and often imperfectly.

In considering this subject of plastic operations upon bone, it is well to remember that osseous tissue has only a slight regenerative power, while the power of the periosteum to form new bone is very great indeed. This is constantly illustrated by the repair of comminuted fractures, the injured bone being restored to something like its former condition, though many fragments may have been lost. One must therefore accept with great caution accounts of the incorporation into the structure of a bone, of bone chips or decalcified bone which surgeons have introduced into a bony gap to hasten recovery. The new bone under such circumstances may have come from periosteal flaps which were not destroyed by the accident.

The integrity of the periosteum is of chief importance in the maintenance of osseous tissue. If, therefore, a flap of bone and periosteum can be so cut as to remain attached to the soft parts, it may be nourished through the pedicle until it unites in a new situation. Many useful operative procedures have been founded upon this principle, but the field is a limited one, because superfluous bone, which may be utilized for the bone flap, will often be wanting in the immediate neighborhood of the bony defect.

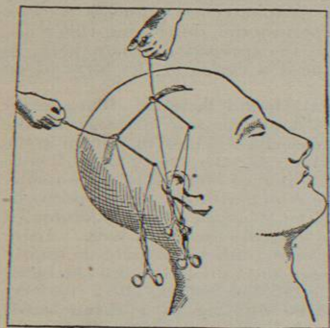

FIG. 651.—Osteoplastic Resection of the Skull by Means of a Gigli Wire Saw. (Gigli.)

Such an osteoplastic resection of bone has been performed upon the skull, upon the bones of an extremity, to restore a deficient nose, to supply an anterior plate to the trachea, et cetera.

Osteoplastic Resection of the Skull.—This operation has been devised to give the surgeon more space than can be safely obtained by trephining. As practically the whole bone is replaced, the flap may be made very large

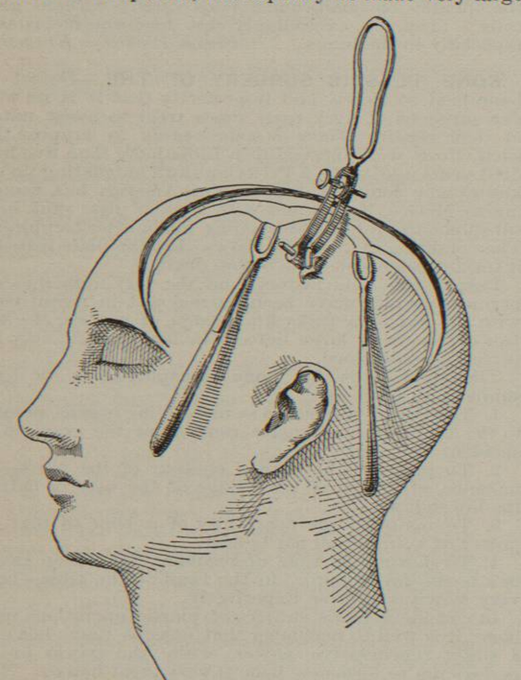

FIG. 652.—Osteoplastic Resection of the Skull by Means of a Craniotome. (Codivilla.)

without risk of leaving the brain unprotected. The operation, which may be carried out in various ways, aims to cut through the bone and soft parts on three sides of a rectangle, or three-quarters of a circle, and then to break the bone on the fourth side without injuring the soft parts or disturbing the vitality of the large bone flap. It has been many times successfully carried out in the past few years. Fig. 651 shows the method of cutting a flap by means of a Gigli wire saw which is passed through very small trephine openings and saws the bone from within outward.

The bone flap may also be cut by chisels or by a craniotome.

When the operation upon the brain is completed, the operator has only to bend back into its original position the flap of skin and bone and to fasten it there by a few sutures. Primary union usually results.

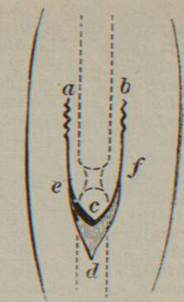

FIG. 653.—Osteoplastic Resection of the Tibia with Retraction of Skin and Bone Flap. (Mueller.)

One of the first operators to make use of a flap of skin and bone was Koenig, whose rhinoplasty, carried out by means of a flap cut from the forehead and twisted downward and stitched in position to make a new nose, is too well known to need detailed description. In a similar manner, other surgeons have successfully operated to close defects in the skull, by taking a flap of the skin and the outer table of the bone and swinging it around over the defect. If the skull is thin it is difficult to split it in this manner; but the periosteum can always be obtained.

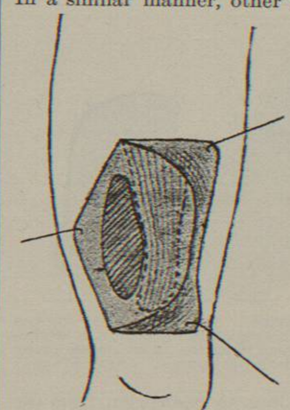

FIG. 654.—Closure of a Defect in the Femur by a Plastic Operation. Skin and fascia reflected; flap of muscle and periosteum marked out. (Ap Schulten.)

Osteoplastic operations upon an extremity, a pedicle being employed to keep up the nutrition until the flap unites in its new position, were described in 1856 by Jordan and Nélaton. Since that time they have many times been successfully carried out. The flap may either be twisted on its pedicle as is done in Koenig's rhinoplasty, or it may be cut from the distal fragment of a defective bone, and retracted so as to fill the gap between the fragments, as is shown in Fig. 653.

A defect in the femur, several inches in length even, may be closed in a similar manner by a flap of muscle and periosteum. The steps in the process, as described by Ap Schulten, are the preparation of the cavity in the bone consisting of free exposure, irrigation, and tamponade with sterilized gauze. Three or four weeks later, when the cavity is lined with healthy granulations, it is cleaned, the site of the proposed flap is exposed by longitudinal and transverse incisions, and a tongue-shaped flap of muscle and periosteum is cut, with its base upward whenever possible, although this is not absolutely necessary. The edge of the bony cavity is cut away at the place

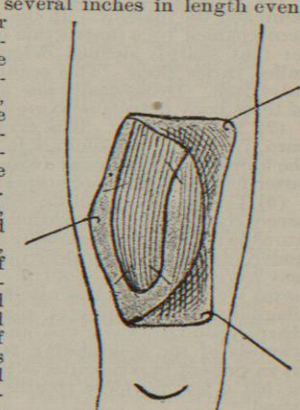

FIG. 655.—Later Step in Same Operation. Flap stitched in position to close the defect in the femur. (Ap Schulten.)

at which the flap is to be bent over it, and a couple of stitches are inserted to hold the flap in position. The drawings (Fig. 654 and 655) sufficiently illustrate the method of procedure.

From the plastic operation already described it is only a short step to one which splits a bone in order to utilize the two portions to make up for the lack of its fellow.

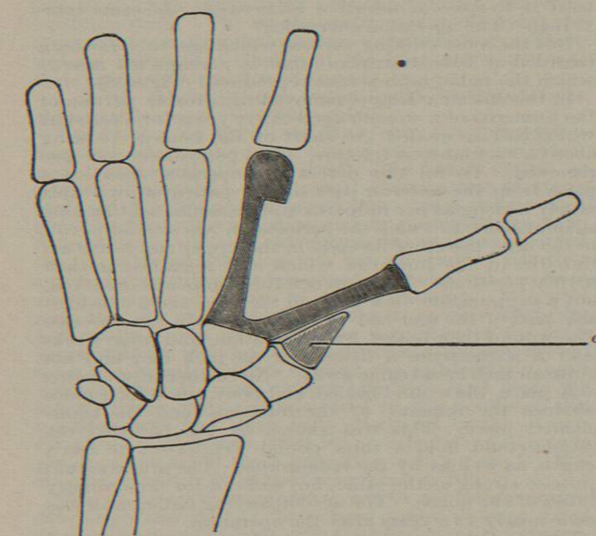

FIG. 656.—Splitting of the Second Metacarpus and Utilization of One of the Parts as a Substitute for the Metacarpus of the Thumb. (K. Cramer.) *a*, Remains of the metacarpus of the thumb.

This has been successfully performed upon the metacarpals and metatarsals, and the ulna has beeen successfully split to piece out the radius.

The use of a less important bone for its fellow, as of the fibula to make good a defect of the tibia, is founded upon the same principle as the operations hitherto described. One of the well-recognized operations for cleft palate consists in chiselling free a strip of bone along either margin of the cleft, and by stitching them in the middle to convert one large cleft into two smaller ones, which can later be closed by a plastic operation upon the soft tissues.

This osteoplastic principle has recently been employed in a most ingenious way to close a defect in the anterior wall of the trachea. Schimmelbusch cut a flap from the sternum of a child aged thirteen years, and inverted it, so that the skin surface was directed toward the lumen of the trachea. The bony surface turned outward was covered with skin from the neck. The wound healed nicely and the plate of bone prevented the sinking in of the anterior wall of the trachea during inspiration, and consequent suffocation which is noticed when such a defect is closed by skin only. König operated successfully upon a seven-year-old child, taking a skin-and-bone flap from the clavicle. The bone sloughed out, but the periosteum lived and became stiff enough to keep the lumen of the trachea intact. Auc describes a similar operation, or rather series of operations, successfully carried out by Sklifossowsky under less favorable circumstances upon a boy aged fourteen years. There was stenosis of the trachea and larynx which had first to be overcome by plastic operations, the skin of the neck being utilized to cover the posterior defect in the tracheal lining. Then the sternal skin-and-bone flap was employed, as in the operations mentioned above. With this variation: the flap of bone was loosened and the skin flap was wrapped around it like a blanket and stitched there. When the wound had so far healed that the bone was completely surrounded by skin, the flap was turned upward and stitched in the tracheal gap. Necrosis of the bone flap was thus guarded against.

The use of a bone flap to heal a defect in bone is limited by the length of the pedicle and the supply of suitable bone in the neighborhood. It is obvious if a piece of bone can be transplanted without a pedicle, the field of this branch of surgery will be much wider. There will then be three sources of bone available, viz., other bones in the patient, the bones of other individuals, and the bones of animals. It seems certain that bone grafts from all three sources have healed in their new beds. Not only do the histories of these patients show that bone so transplanted may become part of the bony structure of the individual operated upon, and not simply remain as a foreign body which is tolerated by the surrounding tissues, but the *x*-ray affords the surgeon a means of actually demonstrating that the implanted fragment may persist and carry out the functions of the bone for which it is a substitute (Fig. 657).

FIG. 657.—Radiographic Photograph of the Actual Condition of the Wrist After the Osteoplastic Operation Described in the Text. (Dubar.)

Dubar resected the wrist of a girl aged nine years for tuberculosis, and inserted in place of the carpal bones that were removed, five fragments from the lower ends of the femurs of a puppy aged eight days. The wound healed primarily. The limb was kept in a plaster-of-Paris splint for six weeks. All the motions at the wrist were preserved. Three years later a small focus of tuberculosis in the fifth metacarpal bone was curetted away. It did not communicate with the wrist. Two years afterward a similar lesion in the fourth metacarpal bone was treated in the same manner. After both of these lesser operative efforts the wounds healed perfectly. Six years after the operation upon the wrist a radiograph was taken (Fig. 657). This showed that the fragments of puppy bone had held their positions and had actually increased in size, fixed in the midst of new-formed fibrous tissue.

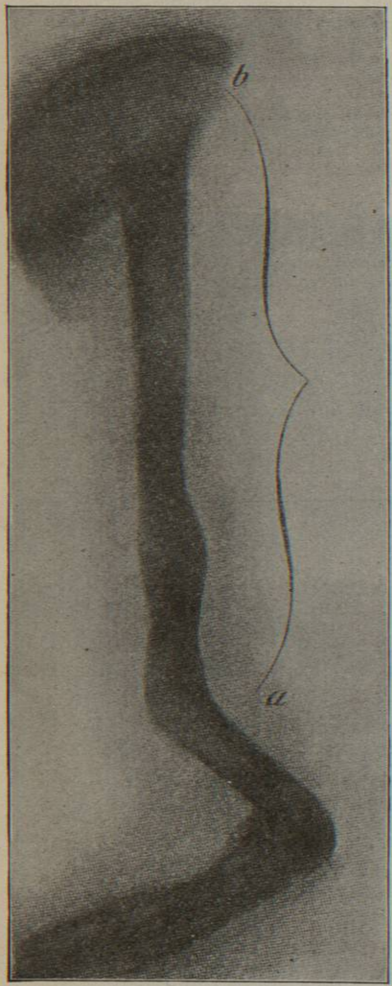

FIG. 658.—Radiograph of Arm, Showing Successful Transplantation of Piece from Tibia to Take Place of Humerus. *a–b*, The portion of bone transplanted. (Klapp.)

Kronacher inserted a piece of calf bone sterilized by boiling, to make good the defect in the first phalanx of the forefinger. The wound was drained and healed by granulation. The finger was kept in plaster of Paris for more than three months, and was finally stiff. New bone formed around the old, as was shown by a radiograph, and the length of the phalanx was nearly normal. The new bone in this instance may have come apparently from undestroyed periosteum.

Lane used a rabbit's femur to make good a congenital defect in the middle of the ulna of a child, splitting the femur and applying the two halves like splints, one to either side of the ulna. In a similar manner he supplemented a defect in an adult ulna resulting from an inflammation of the bone. The results were satisfactory, both patients obtaining perfectly useful limbs.

Ricord removed a large osteosarcoma from the forehead of a woman and utilized the coccyx of a dog to fill the gap in the skull. Five years later the patient died of metastatic growths similar to the original tumor. There was no recurrence at the site of the original tumor and the coccyx was still in place and unabsorbed.

He also made use of the fourth metatarsal of a woman to correct a nasal deformity in the same patient. The operation was in every way successful, and five months later the bone was solid in its new position. Seventeen months after the operation its place had been taken by solid elastic tissue, which was firm enough to still hold the skin over the nose in correct position.

Bramann cut a piece from the tibia of a patient and used it to splice a defective humerus in the same individual. The operation succeeded.

But the most striking success which has thus far been recorded of bone transplantation is perhaps the case of which the radiograph is here reproduced (Fig. 658).

In this instance Klapp removed the greater portion of the humerus of a woman aged thirty years for a sarcoma which had so eroded the shaft of the bone as to bring about a spontaneous fracture. The periosteum was also removed. To fill this defect the operator chiselled a piece from the anterior part of the patient's own tibia nearly as long as her humerus and transplanted this long strip of bone, to which the periosteum was still adherent, to the arm, inserting its ends in the upper and lower extremities of the humerus, which still remained in their normal positions. The most careful asepsis was observed, but a suppuration took place in the arm, and a considerable part of the scar had to be reopened in three weeks. The wound then healed by granulation, and some weeks later a sequestrum a little over an inch long and not quite an inch broad came away. No further suppuration took place, the wound healed, and bony union took place between the remains of the humerus and the transplanted piece. This was shown by the fact that the patient could hold a three pound weight out at arm's length, as well as by the radiograph. The arm was not quite so strong as the other, but sufficed for the ordinary duties of the house. The accompanying radiograph was made nearly two years after the operation.

Though these are isolated examples of successful bone transplantation, and the failures have doubtless been many times more numerous, yet a few well-authenticated successes are sufficient to encourage surgeons to continue their efforts until the conditions under which success is to be obtained are better known. When they are thoroughly understood, a bone graft may be performed with better hope of success. *A priori* there seems to be no reason why a graft of bone from one individual to another of the same species, or a graft from one part of the human body to another, should not grow as well as a graft of skin, or of the thyroid gland. In transplantation of bone from man to man, the possibility of the transmission of disease ought not to be overlooked.

The operations thus far described are difficult of performance and they by no means promise any certainty of result. Is it not possible to close a defect in bone by some simpler method? For this purpose both organic and inorganic material have been used.

Filling Defects with Organic Material.—1. With blood clot.

The most accessible organic substance with which to fill a bone cavity is a blood clot. Schede proposed in this manner to shorten the time of healing. The method is practicable, if the asepsis is perfect, though the length of time required for the organization of the clot is greater than the early advocates of this plan supposed, and the final results are little if any better than those obtained by allowing the cavity to close by granulations. In suitable cases a still better plan is to cut away the edges of the cavity to such an extent that the skin and periosteal flaps may cover the bottom of the defect.

2. With decalcified bone.

Senn suggested decalcified bone as a suitable material to use in filling a bone cavity. It is of course easily sterilizable, and is well tolerated by the tissues. Little by little, if asepsis is perfect, the decalcified bone may be absorbed and its place taken by tissue of new formation, either bone or connective tissue as the case may be. Under such circumstances the permanent result is not better than a strong scar formed by granulation. If the decalcified bone is in a badly nourished portion of the body, it may resist absorption a long time, as shown by the following unique case narrated by C. L. Gibson: Decalcified bone chips prepared according to the directions of Senn had been packed into the cavity left in the head of the tibia after evacuation of a cyst. The skin healed and function and appearance were normal for four and one-half years. Then the scar became inflamed and some chips made their way out through the skin, leaving a sinus. The whole cavity was opened and the chips and loose granulations were curetted away. There was no perceptible change in the bone chips, nor was there any new formation of bone.

3. With calcined bone chips; with sterilized bone chips; with aseptic live bone chips.

The fate of an implanted bone chip has provoked a long and bitter discussion, carried on over a period of some years by Barth and David. The former claims, as a result of numerous histological examinations of specimens obtained from animals and man, that a transplanted bone fragment always dies and is succeeded by new-formed bone; while David claims that at least a part of the transplanted bone does not lose its vitality, but after a period of inactivity it becomes revascularized and lives again as truly as before its transplantation. It would seem that so well defined a problem as this might be easily settled, but the discussion has gone on for some years, without any definite conclusion, although several other investigators have studied the subject and have written upon it, some taking one view and some the other. Those who are interested in the details of this question, will find them fully discussed in the *Archiv für klinische Chirurgie*, 1896–99, an especially full article giving a résumé of those preceding it being one by Fischoeder in vol. lviii. of that magazine, p. 840.

One or two experiments are worth a passing notice. Morpurgo and Martini introduced plates of bone, freed from organic substances, into pouches made in connective tissue. There usually followed a growth of the living tissues into the calcic substance, exactly reproducing the bony structure. The experimenters looked upon this as a new formation of bone from connective tissue, under the influence of the lime salts. Zworykin went one step farther and was able to cause ossification in the heads of rabbits by the introduction of chemical mixtures of lime salts, simulating the mixtures found in normal bone.

It makes little difference to the surgeon, and less to the patient, whether the bone which fills in the gap in his skull is the implanted bone which has retained its vitality, or bone of new formation which has gradually eaten up the implanted bone, using its lime salts for the new bone cells. Indeed, in practical use calcined bone, which all must admit to be dead, is said by many surgeons to be better than chips of living bone. The bone for the purpose should be of a spongy character. The scapula of the calf answers very well for implantation in the skull.

Filling Defects with Non-Absorbable Material.—If the success of these implantation experiments depends not at all on the fact that the bone is alive, and altogether on the aseptic operation, and on the non-irritating qualities of the implanted foreign substance, why confine one's self to organic material?

Teeth may be filled with gold, silver, cement, etc., and no harm follows. Bullets and other foreign substances remain encysted for years. Why not fill bone cavities with some non-absorbable material? Theoretically this is possible, and practically it may be done provided the cavity is not a large one and asepsis can be secured. Stachow has made many experiments in this direction, and has reached the conclusion that a copper amalgam is the material best suited to this purpose. Plaster of Paris, cement, gutta percha, and other substances have been used with a limited success in man as well as in animals: but the chances of future suppuration, even long after the healing is complete, are very great. In certain situations hard foreign substances are well tolerated and are very serviceable. Thus Weir and others have used celluloid for supplying the nasal bridge, although the boat-shaped piece of celluloid is merely slipped under the skin and does not come in contact with the bones. The same may be true when a celluloid plate is inserted to cover the defect left by trephining, or after resection of the lower jaw, as described by Berndt. It was at one time the fashion to preserve a trephine button in salt solution, and to replace it before closing the wound. Experiments upon animals showed, however, that whereas the button might become firmly fixed in position, adhesions between it and the dura are almost sure to follow, even though the operation is of the simplest character. Foreign substances with a smooth surface do not offer such opportunities for firm adhesions, and hence celluloid plates are preferable. Most of the best-known continental surgeons early reported successful cases in which celluloid was thus employed, and with the backing of Fraenkel, Hinterstoisser, von Eiselsberg, Billroth, Winiwarter, Wölfler, and others, the procedure soon became generally known and practised in both Europe and America.

Monara prefers to use a thin plate of cartilage. He says that if its smooth surface is directed toward the brain, no adhesions between the membranes and the cartilage will result.

A hard foreign substance may be used as a guide to the periosteum in its attempt to form new bone. C. Martin made a skeleton of platinum-iridium wires the shape of the bone that was lost and succeeded in getting the periosteum to grow a new bone almost the shape of the old. Immobility is essential to the success of such procedures, and hence they yield better results in the forearm and leg than in the upper arm and thigh, since the sound bone acts as a closer splint than any external apparatus can possibly do. In Martin's successful cases, the supports remained permanently incorporated in the regenerated bones. As such apparatus usually needs fitting during the operation, the vise, files, pincers, and whatever other tools are required should be sterilized, as well as the instruments needed for the operation upon the patient. This is equally true when celluloid or other solid material is introduced. *Edward Milton Foote.*

BONE-SETTING.—In every country there is a class of irregular practitioners who make a living, and sometimes also quite an extensive reputation, by their success in restoring functional usefulness to crippled limbs. These individuals are, as a rule, most arrant quacks, knowing absolutely nothing of anatomy, or of the pathology of the conditions which they are called upon to treat, and yet they are often successful to a remarkable degree in curing certain joint affections which may have baffled the skill of the most experienced and able surgeons. These men are known as bone-setters, from their invariable assertion, made often through honest ignorance, that "the bone is out of joint, and only needs to be set." It is true that they frequently inflict most serious injury, which may lead to loss of limb or life itself, yet it is also undeniable that they sometimes restore a limb which might otherwise remain permanently crippled, or even be sacrificed as a useless incumbrance. Such being the fact, it is not the part of wisdom to seek to ignore the existence of bone-setters, or to allow their failures to blind our eyes to their successes; but we should rather study their methods, to learn wherein lies the secret of their triumphs, and then we may with benefit and without any loss of dignity imitate their treatment in suitable cases, easily avoiding, through a knowledge of anatomy and pathology, the pitfalls into which they, in their ignorance, so often plunge.

Dr. Wharton P. Hood[1] was the first to study intelligently the methods employed by bone-setters, and it is to him that most of our knowledge of this art, for art it is, though no science, is due. He defines bone-setting as "the art of overcoming, by sudden flexion or extension, any impediments to the free motion of joints that may be left behind after the subsidence of the early symptoms of disease or injury; perhaps, indeed, more frequently of the latter than of the former." The cases that most frequently fall into the hands of bone-setters, and are cured, to the joy of the patient, but to the discredit and loss of reputation of the regular practitioner, are those of slight fibrous ankylosis, of a degree sufficient to limit motion and impair the functional utility of the limb, yet not such as apparently to demand forcible rupture, an operation so unreasonably dreaded by many surgeons. In such a case, perhaps, some feeble attempts at passive motion are made. The joint is flexed cautiously and slowly, until the patient complains bitterly of pain; then the operator desists, orders the limb to be kept at rest, and bathed with lotions to subdue the inflammation excited by the strain put upon the adventitious bands. A few days later, when the heat and swelling have disappeared, the same manipulations are repeated, and followed again by inflammation and its treatment. After a number of repetitions of this sort the patient sees that he is no better than before, and refuses to submit his joint to any further manipulations. Then he becomes discouraged, limps around with the aid of a cane or crutches, and tries to bear philosophically the thought that he is a cripple for life. But at last some friend tells him of a wonderful cure performed by a bone-setter in a case apparently similar to his own, and in desperation he sends for the quack. The latter assures him that the bone is out and only needs to be replaced. He orders the joint to be enveloped for a time in flaxseed poultices, probably a procedure that contributes in no way to the success of the operation, and then on the appointed day meets his patient, seizes the limb, and with a quick motion flexes and extends the joint to its full extent, breaking up all the adhesions, and the patient finds that he is cured. The pain of the operation is but little greater than that inflicted by the regular practitioner in his feeble and ineffectual attempts to restore motility, and the resulting inflammation is usually slight or nil. The quack says that the bone is restored to its place, pockets his fee, and retires with glory.

This is no exaggerated picture, but is a true tale of what actually occurs in not a few instances, as many practitioners will sorrowfully admit. The good that bone-setters do is in these cases of partial ankylosis, and it is because they are unable to discriminate between the different conditions in which joint motion is impeded that they so often inflict irreparable injury. No surgeon would attempt forcibly to move an articulation which is the seat of strumous or tuberculous inflammation, yet this is what the bone-setter does with dire result. In most of the joints which can be benefited by forcible movements there is a tender spot, usually about the inner side, for which the bone-setter always feels, and the discovery of which is to him a sign of ultimate success. The motion of the joint is not absolutely abolished, but is limited in certain directions, and any attempt to pass this limit causes pain. The skin over the articulation is not hot, and all the other signs of inflammation, except perhaps a slight serous effusion, are absent. The following is an enumeration of the location of these painful spots, together with Mr. Fox's explanations of their occurrence, as given by Mr. Edward Cotterell in a very practical little work treating of the minor injuries of the limbs.[2] 1. "Over the head of the femur, in the centre of the groin, corrresponding to the ilio-femoral band of the capsular ligament (which is most severely stretched when the thigh is over-extended, as when the trunk is flung violently backward, the commonest cause of a sprained hip). 2. For the knee joint, at the back of the lower edge of the internal condyle; in other words, at the posterior border of the internal lateral ligament, where it blends with Winslow's ligament, and where the semimembranous tendon is in intimate relation with it. These parts suffer most because, as Mr. Morris says, 'during extension they resist rotation outward of the tibia upon a vertical axis, and a sprained knee is almost always caused by a twist outward of the foot.' 3. For the ankle, on the front of the external malleolus, the apex of the plantar arch, and the tip of the fifth metatarsal bone. 4. For the shoulder, at the point corresponding to the bicipital groove, because in nine cases out of ten a man sprains his shoulder to prevent himself from falling; his hand grasps the nearest support, the body is violently abducted from the arm, the long head of the biceps is called upon to exert its utmost restraining power, the bicipital fascia is overstretched, and the tendon very often misplaced. 5. For the elbow, in front of the tip of the internal condyle; the fan-shaped internal ligament has its apex at that point, and it is most stretched in over-supination with extreme extension of the forearm. 6. For the wrist, the styloid process of the ulna, and the annular ligament in front of the wrist."

The injuries or diseases most likely to give rise to the slight degree of ankylosis which is amenable to the bone-setter's manipulations are rheumatism and gout, displaced tendons or cartilages, sprains, prolonged immobilization during the treatment of fractures, neuromimetic joint affections treated improperly by rest and mechanical support, and ganglions.

The bone-setter's manipulations consist in first locating the painful point, upon which the thumb is firmly pressed during the remainder of the operation; and then, while the operator steadies the proximal segment of the limb, the distal segment is grasped and rotated as much as possible on its axis in order to overcome, as far as may be, muscular resistance; this being accomplished, the joint is sharply flexed or extended in the direction of greatest resistance, and then the reverse movement is made until all the adventitious bands are broken, or until the "bone is put back," in the bone-setter's own phraseology. The rupture of these bands of adhesion is often accompanied by a loud report. For a description of the special manipulations required for each joint, the reader may consult the work of Wharton Hood, above referred to.

It should not be forgotten that most of these stiff joints may be prevented by a proper attention to the treatment of minor injuries of the articulations, and this is one of the principal lessons which we may learn from the bone-setters. If surgeons would never dismiss a case of fracture or sprain until joint motion were perfectly restored, the occupation of the bone-setter would be less lucrative than it now is.

[1] On Bone-Setting (So-Called), and Its Relation to the Treatment of Joints Crippled by Injury, Rheumatism, Inflammation, etc. By Wharton P. Hood, M.D., M.R.C.S., London and New York, 1871.

[2] On Some Common Injuries to Limbs: Their Treatment and After-Treatment, Including Bone-Setting (So-Called). By Edward Cotterell, M.R.C.S., Eng., L.R.C.P., Lond., London, 1885.

BONES, TEETH, AND CARTILAGE, CHEMISTRY OF.—The *bones* of vertebrates consist essentially of an organic basis of ossein and the so-called bone earths made up of inorganic salts. Elastin, fat, proteids, and nuclein are also present. Ossein is identical with or very similar to the collagen of connective tissue. In the bone earths calcium predominates in the bases, but small quantities of magnesium are also present and, according to some authors, traces of potassium and sodium. These bases are for the most part in combination with phosphoric acid, but some carbonic acid is found, and traces of chlorine and fluorine. The sulphuric acid mentioned by some writers is probably derived from some of the organic constituents and does not properly belong to the bone earths. There is some difference of opinion as to how the bases and acids are combined, but according to Gabriel the simplest expression for the composition of the ash is $[Ca_3(PO_4)_2 + Ca_5HP_3O_{13} + Aq]$ in which two to three per cent. of the lime is replaced by magnesia potash and soda and four to six per cent. of the phosphoric acid by carbon dioxide, chlorine, and fluorine. As age advances the bones become richer in ash and poorer in water. Hoppe-Seyler gives the following composition for undried bone without separation of marrow or blood: Water, 50 per cent.; fat, 15.75 per cent.; ossein, 12.40 per cent.; bone earths, 21.85 per cent. The composition of the bone earths is given as follows by Zalesky in parts per thousand:

	Man.	Ox.
Calcium phosphate, $Ca_3P_2O_8$	838.9	860.9
Magnesium phosphate, $Mg_3P_2O_8$	10.4	10.2
Calcium combined with CO_2, Fl, and Cl	76.5	73.6
CO_2	57.3	62.0
Chlorine	1.8	2.0
Fluorine	2.3	3.0

Bone marrow is composed chiefly of fat (96 per cent.), containing the fatty acids of ordinary adipose tissue in the proportion of palmitic acid 22, stearic acid 10, and oleic acid 63 per cent. of the total fatty acids. Proteid is present in small quantities, especially in the red marrow of the spongy bones. It is principally in the form of globulin and nucleo-albumin, with traces of albumin. Among the extractives of marrow are lactic acid, hypoxanthin, and cholesterin.

The teeth consist of crusta petrosa, dentine, and enamel. The crusta petrosa is a true bony structure and resembles ordinary bone in composition. Dentine is very similar in composition, but contains less water. Enamel is an epithelial structure containing scarcely any water but rich in lime salts. Its organic constituents differ from the ossein of bone and dentine in not yielding any gelatin on boiling. The following composition is given for the teeth by Hoppe-Seyler from analyses by Aeby:

Constituents.	Dentine.	Enamel.
$Ca_{10}CO_3(PO_4)_6$	72.06	96.00
$MgHPO_4$	.75	1.05
Organic substances	27.70	3.60

Cartilage.—The organic basis of cartilage was formerly known as chondrigen and the gelatin-like substance obtained from it on boiling was known as chondrin; but it is now recognized that the so-called chondrigen is a mixture, containing the following as its chief constituents.

1. Collagen, resembling closely that of connective tissue.
2. An albuminoid substance, resembling elastin but richer in sulphur.
3. A mucin-like substance, known as chondro-mucoid and capable of decomposition into a proteid and chondroitic acid.
4. Chondroitic acid or chondroitin-sulphuric acid, present in combination in chondro-mucoid and also uncombined. Schmiedeberg ascribes to chondroitic acid the formula $C_{18}H_{27}NSO_{17}$.

The inorganic constituents of cartilage are characterized by the abundance of sodium which in adult mammals is principally combined with sulphuric acid. In mammalian embryos and in lower vertebrates the sulphuric acid is largely replaced by chlorine. The composition of cartilage is summarized by Hoppe-Seyler as follows:

In 1,000 parts.	Costal Cartilage.	Articular Cartilage.
Water	676.6	735.9
Solids	323.3	264.1
Organic	301.3	248.7
Inorganic	22.0	15.4

Salts in one hundred parts of ash:

Potassium sulphate	26.66
Sodium sulphate	44.81
Sodium chloride	6.11
Sodium phosphate	8.42
Calcium phosphate	7.88
Magnesium phosphate	4.55

Wesley Mills.
William S. Morrow.

BORAGE.—The leaves and flowering tops of *Borago officinalis* L. (fam. *Boraginaceæ*). A European or Oriental plant, occasionally cultivated in flower gardens in the United States. It has a succulent, branched, hairy stem, half a metre or so high (twenty inches), with rough, coarse-looking, entire leaves, and terminal one-sided cymes of pretty blue flowers. Borage has been a domestic medicine in Europe for years. Its odor is slight, at least when dry; taste, bland and mucilaginous. It contains no more active principles than mucilage and nitrate of potassium, and its medical qualities are only those of a mild demulcent.

W. P. Bolles.

BORDIGHERA.—A marine health resort on the Mediterranean coast of France, 10 miles east of Mentone and 3 miles west of the Italian boundary.

"Bordighera is a conspicuous object nearly all along the western Riviera, as it is seen glittering in the sunshine, its houses clustered together on a promontory that projects far out into the sea. It is the only health resort on this coast that occupies a position on a promontory; all the others being built round bays or depressions in the coast. It is naturally, therefore, much exposed to winds, that is to say, to all those winds that can reach it in blowing across the sea; the east, the southeast, the southwest, and the west winds can all blow freely upon this promontory. But it is well protected by mountains to the north, northeast, and northwest, whence the coldest winds come. Moreover, it must be remembered that all the winds that reach it must, on account of its position, come to it from the sea, and impregnated with saline emanations. And this is the sole distinguishing characteristic of the climate of Bordighera as compared with that of neighboring stations; the predominating influence of sea air rendering it essentially bracing and tonic" (Burney Yeo).

Bordighera is a small town of 2,500 inhabitants, and the portion devoted to invalids is called the "new town," or English quarter, and is on level ground to the west of the promontory. The hotels and villas are surrounded by groves of olive, lemon, and palm trees. The latter grow to a great height and are said to be more plentiful than in any other part of the Italian Riviera. "It is said that there are more palms in the neighborhood of Bordighera than in the whole of Palestine" (Dean Alford). The natives have a monopoly of supplying the Vatican with palm leaves for Palm Sunday. Dense olive groves also cover the plain upon which the new town is situated. The drainage of the town is primitive, but the place is said to be healthy, and the hygienic conditions are considered good. The water supply is obtained from wells, and from a spring in the flank of Monte Nero (Goodchild). During a residence of fifteen years Dr. Goodchild has seen no case of typhoid fever or diphtheria among the members of the English colony.

The average monthly temperature for the months from October to May inclusive is as follows:

MEAN TEMPERATURES, 1876–79.

October	63.5° F.	February	49.1° F.
November	55.0° F.	March	50.5° F.
December	49.0° F.	April	55.1° F.
January	49.6° F.	May	61.0° F.

The temperature averages about three degrees lower than that of Mentone, according to Dr. Goodchild, and the range is smaller. The relative humidity approximates to that at San Remo, which has a yearly average of 66.7 per cent. The rainfall also is about the same as at San Remo, at which place the number of days on which rain falls during the season is thirty. "At Bordighera the mistral is the west wind, being turned completely in that direction by the mass of mountains behind Monaco, and from being forced to blow over the sea it loses somewhat of its dry and cold character" (Burney Yeo). "The soil upon the hillsides is limestone and conglomerate, but upon the flat it is composed of old sandy sea beaches, in which the water rapidly finds the sea level. About a couple of acres near the English church possesses a soil, however, in which there is a small admixture of clay and which is somewhat damp in consequence" (J. A. Goodchild, M.D.).