swirl in eddies and, as in aneurism, predisposing to thrombosis. Efforts have been made to prevent this dilatation by turning the vein back on itself, like a cuff, and by suturing the surrounding tissues over it. We suggest a third method, which might be employed in suitable cases of thrombosis. Since in many instances of intravascular coagulation the intima alone is at fault, it has occurred to us that, instead of resecting the artery, its internal coat might be peeled out, and replaced by a piece of vein. This would leave the outer coats of the artery as a firm support for the vein, and the vein would form a new lining membrane for the artery. In some cases of traumatic thrombosis it would probably not be necessary to remove even the tunica intima before placing the vein in position.

5. *Catheterization* of the arteries of a stump left after amputation for arteriosclerotic gangrene, in order to remove clots and thus minimize the risk of necrosis of the flaps, was suggested by Severeanu in 1894. As the passage of catheters and probes into an artery can serve only to injure its delicate endothelial lining and encourage thrombosis, we believe the procedure to be harmful rather than beneficial.

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STATED MEETING, FEBRUARY 1, 1915

The President, Dr. John H. Gibbon, in the Chair

INGUINAL LYMPHOMA

Dr. D. L. Despard presented a man who had been operated on at the Jefferson Hospital for enlarged inguinal glands. The glands on the left side, smaller than those on the right, were not removed; the largest of the glands of the right side measured, three or four days after removal, 4 cm. in diameter. Microscopic examination showed simple hyperplasia of the lymphatic glands, without increase in the fibrous tissue and no evidence of eosinophiles except here and there; nothing to suggest sarcoma or Hodgkin's disease. The cells had the appearance of ordinary lymph cells. History was practically negative. There was no venereal history; Wassermann, negative. He had, however, a leucocyte count of 12,000. The red cells were increased in number to 6,200,000. Beyond this the blood picture presented nothing unusual. The differential count showed polymorphonuclear cells of 66 or 67 per cent., in other respects it was practically normal. The reporter said that he had never seen an ordinary hyperplasia in which the glands were as large as those on the right side in this case. The question is whether this is an incipient Hodgkin's disease or a pre-sarcomatous condition.

Dr. John H. Jopson said that this case is similar to one in which he had operated for polyglandular enlargement of one side of the neck. Some of the glands were found to be broken down at the time of operation, and the appearance seemed to disprove the possibility of Hodgkin's disease or sarcoma. Pathologists in two laboratories reported the condition tuberculous. There was local recurrence and a second operation was done some months later. This time the glands were examined by Dr. Canby Robinson who reported typical Hodgkin's disease.

OPERATION FOR OLD FRACTURE OF THE PATELLA

Dr. John H. Jopson presented a woman thirty-nine years of age, weighing over 200 pounds, who fell in 1912 and fractured her left patella. She was treated by another surgeon without operation, some form of an extension apparatus being applied to the muscles of the thigh to aid in bringing about apposition of the patellar fragments. She was in bed for two months; there was marked stiffness of the knee following the removal of the apparatus. Four months after the original accident, the fragments became separated during passive motions. She was again in bed for one month. Considerable stiffness persisted and she had some effusion of the joint, but finally she got around with a cane.

In December, 1913, she fell again, injuring this knee. When examined by the reporter, February, 1914, a wide separation of the patellar fragments was found, at least two inches when the limb was extended and correspondingly more when it was flexed. The femoral condyles were plainly felt between the fragments and there was apparently no union. There was a complete loss of power of extension in the knee and the patient could walk only with a cane and had no confidence at all in the strength of the limb. X-ray examination showed two fragments, each of good size, widely separated (Fig. 1). At operation, in March, 1914, the fragments were exposed by the usual curved incision, convex downward. The fragments were connected by a broad, very thin, relaxed sheet of fascia, which permitted complete flexion, but was of no service in extension. There were many adhesions around the fragments and the quadriceps muscle. The broken edges were covered with a thick layer of fibrous tissue. The first step toward approximation of the fragments was a division of the lateral expansions of the quadriceps and loosening of the under surfaces of the two fragments from their adhesions to the underlying bones. A plastic operation was done on the quadriceps tendon by making a V-shaped incision with the apex downward, which manœuvre diminished by about two-thirds the distance between the fragments. The vastus internus and externus were extensively mobilized. As it was still impossible to approximate the fragments, they being about three-quarters of an inch apart, the tubercle of the tibia was chiselled loose from the bone, remaining attached to the patellar tendon and the periosteum on each side, which permitted of its being elevated about ¾ of an inch and the fragments of the patella could then be brought into contact, there being some slight tilting of the lower fragments. Both fragments were drilled and a heavy silver wire and two chromic catgut sutures were used to fasten them together. A wire nail was driven through the separated tubercle into the head of the tibia at its new level. The lateral expansions were sutured, the quadriceps tendon repaired, the thin, tendinous flap formerly uniting the fragments used to overlap them. The fat, fascia and skin wounds were sutured, and drainage provided at either angle, the wound being dressed on a posterior splint. There was some superficial necrosis of the fat due to the prolonged manipulation at operation, otherwise convalescence was normal. A splint was worn for three months, passive motions

FIG. 1.—Separation of patellar fragments. Before operation.

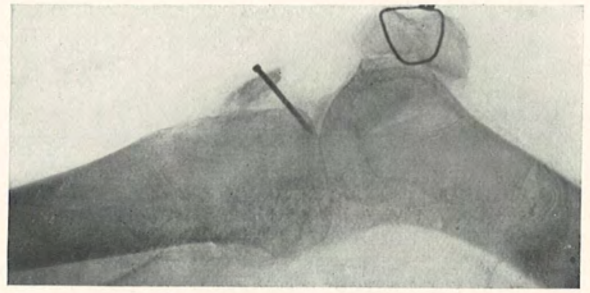


FIG. 2.—Condition after operation; patellar fragments in apposition, tibial tubercle moved upward and fastened by pin.

being practised after the wound was healed. There was marked stiffness at first, but this yielded to passive motion and massage. At the present time, the result is as follows: Flexion is almost complete, extension is strong to a point 15 or 20 degrees from the straight line, passive extension is perfect. The patient can walk long distances. She can stand with all her weight on the leg. The patella is movable and the only disability is in going up and down stairs, when she still fears to bring the injured knee ahead of the other. The X-ray (Fig. 2) shows excellent apposition and union of the fragments, union of the tubercle of the tibia with some tilting, and the nail, which still remains, has worked into an oblique position in the head of the tibia, but causes no annoyance. The incompleteness of extension is probably due to the high insertion of the patellar tendon with some loss of lever action in consequence.

The case illustrates what can be done in old fracture of the patella, with wide separation, by a combination of a plastic operation on the quadriceps tendon with von Bergmann's method of elevation of the tibial tubercle. Either of these measures alone would have been insufficient to secure approximation in this case, and, while the former has been criticised for resulting in a weakening of the muscle and the latter for not accomplishing very much in the way of approximation, the combination of the two in this case has resulted in a strong, useful limb. One criticism which might be aimed at the elevation of the tibial tubercle is one used by Turner, that it may prejudice the mobility of the joint. There is some slight loss of the power of complete extension here, although this may in time be overcome.

Dr. George G. Ross spoke of a case in which the interval between the time of the accident and of operation was five years. There was a separation of from 2¼ to 2½ inches between the fragments. He was able to bring the two fragments together, apparently in perfect apposition, secured by heavy silver wire. Fourteen days later, the patient being still in bed, the wire was snapped by a contraction of the quadriceps muscle, producing a ⅜ inch separation. She went about in this condition for a year and then the broken end of the silver wire produced a sinus, for which operation was done. While under the anæsthetic another attempt was made to bring the fragments together. They did not get bony union but a good strong fibrous union with good functional result, giving the woman a very useful limb. The problem in this case to be overcome was atrophy and shortening of the quadriceps muscle. No operation upon the tendon was done. It was forced down, but was not successful in entirely overcoming the shortening of the muscle.

TRANSPLANTATION OF ENTIRE BONES WITH THEIR JOINT SURFACES*

By A. Bruce Gill, M.D.
of Philadelphia, Pa.

The following experiments in bone transplantation were undertaken to determine whether or not it is possible to secure the healing in of entire bones with their articular surfaces, and whether or not such bones, if they do become healed in, will remain alive and unabsorbed, and, finally, to observe any other conditions that may have a bearing upon the subject of bone transplantation in general.

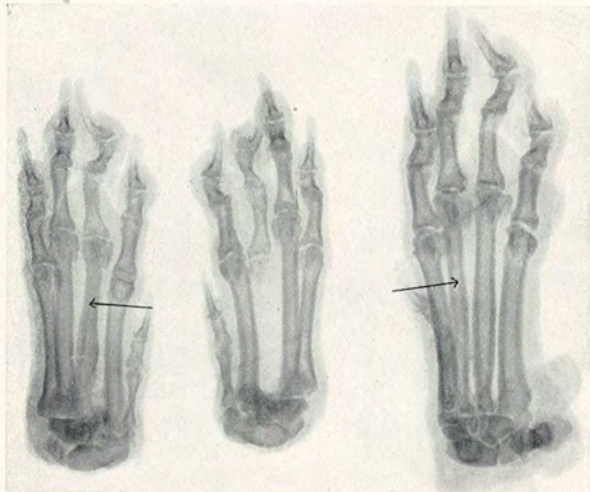
Full-grown dogs were operated upon under complete surgical anæsthesia by ether. The second long metatarsal bone was excised in the front paws and each one was implanted in the opposite paw. The ends of the bone were held in position by chromic catgut sutures. Tendons and fascia were sutured over it with interrupted sutures of silk floss. Asepsis was attempted by shaving the paws and painting the skin with tincture of iodine and by clamping the margin of the incision to sterile towels. After the incision was closed it was painted with tincture of iodine. No dressings were applied and the dogs were permitted to walk about. This they usually did on the day following operation without any evidence of pain.

Experiment No. 1.—Operation January 30, 1914. Periosteum scraped from the bone implanted in the right paw. Both skin wounds broke down a few days after the operation. The left paw was entirely healed on February 18, but the right presented a discharging sinus. On March 9, the exposed metatarsal was removed from the right paw under ether anæsthesia. April 4, both paws healed, dog walks and runs on both feet without a limp. October 16, dog killed. X-ray picture of paws shows the metatarsal present in left paw. Marrow cavity narrowed and irregular but persistent throughout the length of the bone except at proximal end, which shows evidence of the suppuration that occurred after the operation. The metatarsophalangeal joint is apparently normal. In the right paw only about one-half of the distal extremity of the transplanted bone remains.

Experiment No. 2.—Operation February 19, 1914. February 24, both wounds wide open to the fascia. February 26, dog killed, as a part of the left transplant was exposed. The other half of it was found to be firmly embedded in granulation tissue which was firmly adherent to the bone except at the joints. The other transplant was completely embedded in granulation tissue which was

* Read before the Philadelphia Academy of Surgery, February 1, 1915.

Fig. 1.—Experiment No. 1.



No. 3. No. 4.
Fig. 2.—Experiments No. 3 and No. 4.

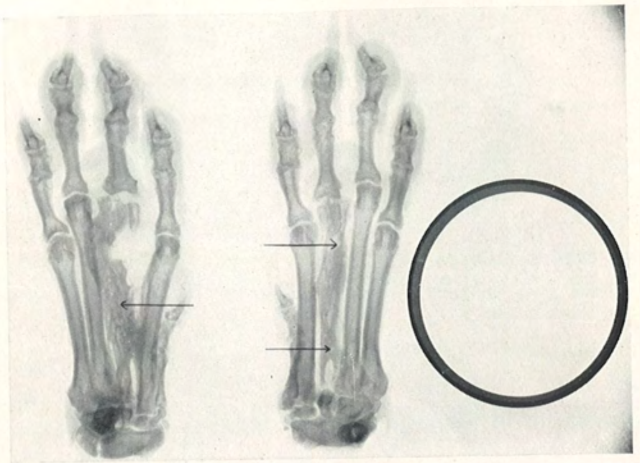


Fig. 3.—Experiment No. 5.

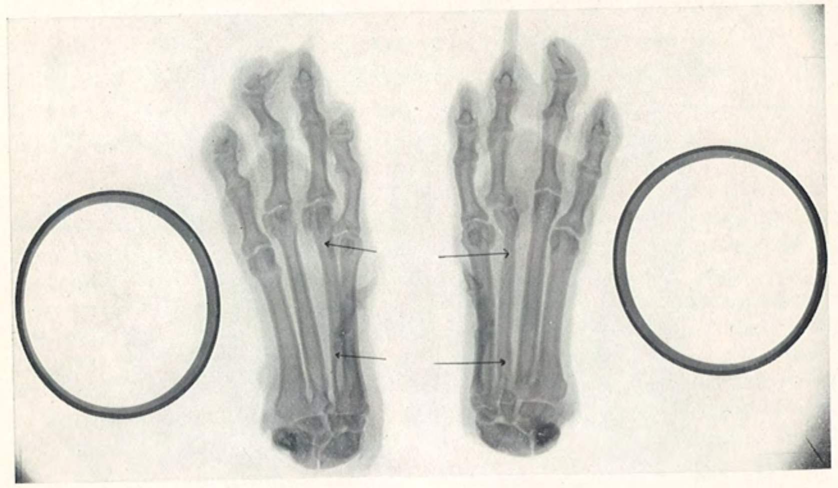


Fig. 4.—Experiment No. 6.

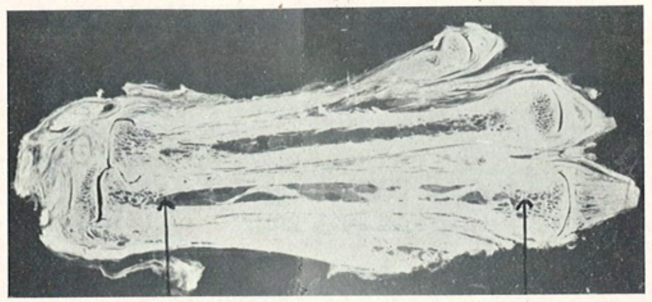


Fig. 5.—Photograph of section of paw.

Fig. 6.—Photograph of section of paw, mounted in celloidin.

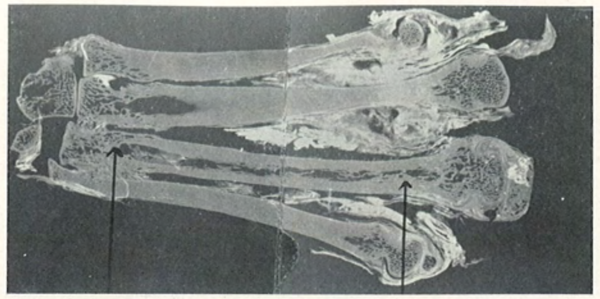


FIG. 7.—Photograph of section of paw.

FIG. 8.—Photograph of section of paw, mounted in celloidin.

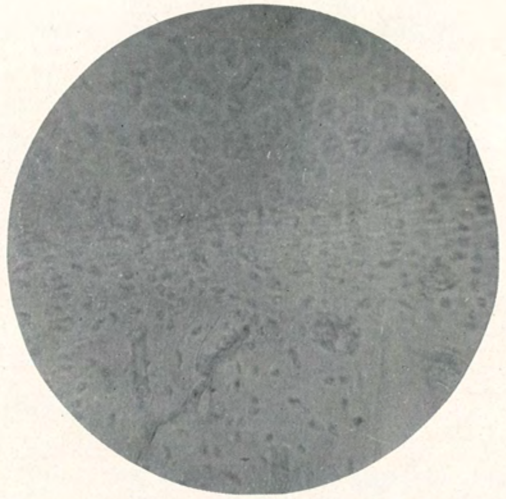


FIG. 9.—Microphotograph of transplanted bone, showing joint cartilage above and bone below. Cells of both are well stained.

firmly adherent to the bone except at the joints. The bone was torn out with considerable force, and soft tissue remained clinging to it.

Experiment No. 3.—Operation February 25, 1914. One metatarsal broken in removal and not implanted. March 17, small sinus present. Dog walks without limp. May 6, small persistent sinus. June 15, healed. October 16, dog killed. X-ray shows transplanted bone present and apparently normal, except for slight irregularity in proximal end. Both joints apparently normal.

Experiment No. 4.—Operation February 26, 1914. March 9, skin wounds open to the fascia, right discharging pus. March 17, almost healed. Dog has distemper. April 29, small sinus in right paw, left remains healed. May 6, right paw healed. October 16, dog killed. X-ray of left paw: Transplanted bone all absorbed except small distal fragment. Right paw: the bone is present, marrow cavity very narrow, proximal half of bone thick and irregular. Distal joint normal, proximal joint obscure. The other metatarsals and the tarsal bones also present evidence of the suppurative process.

Experiment No. 5.—Operation March 18, 1914. March 25, wounds both open to the fascia. April 2, wounds healed above and open below. April 29, suppuration in both paws. October 9, healed. October 23, dog killed. X-ray of left paw: Transplanted bone shows marked evidence of the long suppuration; thickened, irregular, proximal end absorbed for about one-fourth inch. Right paw: Bone much distorted, proximal ends of two other metatarsals also slightly involved. Distal joint good.

Experiment No. 6.—Operation March 19, 1914. March 25, left is healed, did not break down. Right is open below. April 2, both healed, no lameness. October 23, dog killed. X-ray of left paw: Transplanted bones present, a little thinner than normal; proximal extremity a little irregular, otherwise like other metatarsals, dislocation of distal joint. Right paw: Transplanted bone apparently normal throughout.

Summary.—Eleven bones were transplanted. One dog was killed a week after operation, before healing in of the bones had occurred, and in another dog one transplant was removed under ether. The remaining eight transplants healed in after more or less suppuration of all wounds but one. The dogs were killed from seven to eight and one-half months after operation. One of the eight healed-in transplants was found to be almost all absorbed. Another is badly distorted and a second moderately changed as a result of osteomyelitis following operation, but they appear to be serving their function and they present evidence of new bone formation. The remaining five transplanted bones are practically normal in appearance. The articular ends of the bones are apparently normal and the joints have perfect function except in those cases where the end of the bone was destroyed by the suppurative process.

Microscopic examination of the transplanted bones that healed in with little or no suppuration of the wounds shows no evidence of dead bone anywhere. The bone cells as well as the cells lining the marrow cavity and the cells of the periosteum are well stained. If there was necrosis of the transplanted bone, the necrotic part has all been absorbed and replaced. The joint cartilage also appears normal.

The operations were performed by the writer without assistance. This rendered it necessary to fasten the paws of the dogs securely to blocks of wood. The straps caused venous constriction which prevented complete hæmostasis and delayed the operations. These conditions probably caused the breaking down of the wounds and the subsequent suppuration. In experiment No. 6 this condition of venous constriction was avoided and the one paw healed by first intention and the other healed promptly after it had opened up slightly. I believe that practically all cases could be operated upon with primary union under favorable conditions and consequent healing in of all transplanted bones.

The fact that so many of them healed in under unfavorable conditions and in the presence of infection shows the marked resistance of the transplant. The articular ends of the bones and the joint cartilage show an equal ability with the remaining portion to maintain their life and resist infection. In these experiments the joints emerged from their trials in fully as good condition as the bones proper, and it should follow that the transplantation of half-joints and entire joints should present no greater difficulty or uncertainty than the simple transplantation of bones of equal size.

The fact that the dogs went about on their paws almost immediately following the operation does not necessarily affect the transplanted bone adversely. To the contrary, the functioning of the transplant may be a favorable factor in its life and regeneration.

These experiments would seem, therefore, to indicate that the smaller long bones with their articular surfaces are readily transplantable in the dog under unfavorable conditions, and that the joints are re-established and preserved thereafter.

In the successful transplantations the bones are found at the end of seven to eight and one-half months to be normal in outline and structure, to be living and to show no evidence of necrosis or absorption of any of their parts, in short, to be indistinguishable from normal bone. They have not been in contact with other bones except through their articular surfaces. We must therefore conclude either that the transplanted bone has retained life in itself or that it has been completely regenerated in all of its parts by a process of metaplasia of cells derived from the surrounding soft tissue. Murphy's theory that

a transplanted bone is only osteoconductive and that it must contact with fresh living bone is absolutely inapplicable to these experiments.

The metaplasia theory of bone regeneration from the surrounding connective tissue cells is maintained by Baschkirzew and Petrow, whose views, based on animal experimentation and clinical observations, are entitled to some consideration, if only to expose their fallacy. They state that the majority of bone transplants soon die: although a few stronger or better nourished ones may live a long time, until they also die of exhaustion. Some few heal in and regenerate new bone. Young connective tissue cells are the chief factor in the regeneration of new bone in a transplant which is imbedded in muscle. They penetrate into the vascular and the Haversian canals and are converted into osteoblasts and bone cells. The transplanted periosteum and endosteum become in part necrotic, while the remaining part is possibly capable of bone regeneration. But the persistence of such new bone is questionable and its differentiation from the bone which grows from the connective tissue cells is often impossible. The preservation of the periosteum is not essential to the life of the transplant, but it evidently is useful in causing more rapid union between the transplant and the surrounding tissues, in hindering resorption of the transplant, and in giving the first impulse to new bone formation.

This view of metaplasia does not agree with the views of most other investigators of this subject. Nor, if pushed to the limit, does it seem tenable. If the entire transplant has died and if later we find the transplant to be alive, then it is necessary to suppose that all its parts, periosteum, marrow, endosteum, bony tissue, have been regenerated from young connective tissue cells from the surrounding structures. But if these tissue cells are capable of such metaplasia, why do they not perform such function at all times, why do they wait until a dead transplant is thrust into their midst, or why do they not do it when a piece of decalcified bone or other porous substance is implanted? It becomes necessary to suppose that in some unaccountable manner the dying transplant stimulates the metaplasia. The same process must necessarily occur in every simple comminuted fracture. And all this theory in the face of the fact that bone contains within itself the elements necessary to its growth and regeneration. Why then should it borrow from the outside?

As a matter of fact, Baschkirzew and Petrow do not push their theory to its rational conclusion. They admit that certain parts of the transplant do regenerate new bone, but say that such bone often cannot be differentiated from the bone which grows from the connective tissue cells. How then can they differentiate the latter from the former? Finally, the thorough microscopic studies of Phemister, Mayer and Wehner and many others show that certain parts of the transplant are osteogenetic. The latter investigators give careful consideration to Baschkirzew and Petrow's theory and point out the errors in their experiments in not excluding bone derived from the osteogenetic layer of the periosteum and from adjacent Haversian canals.

All the evidence and all the weight of authority is against the view of regeneration by metaplasia. We must conclude that a transplanted bone retains life in itself and is capable of its own regeneration as far as is necessary.

For clinical purposes this is all that is necessary to be certain of in the transplantation of bones. And yet it may be of value to know, for example, whether or not we should remove the periosteum from the transplant. This opens up to us the entire question of the rôle played by each part of a bone transplant, what parts live and what parts die, what parts regenerate bone and what do not.

At first view one is confused by the opposing views of such men as Barth and Murphy, Axhausen, Macewen, and Baschkirzew and Petrow with their numerous followers or predecessors. Their views are often diametrically opposed and they cannot all be right. But much of this confusion will disappear on careful study and comparison of the various statements and theories, and I think we are able at the present time to arrive at conclusions fairly close to the truth.

In the first place, certain words, such as periosteum, marrow, bone graft, do not have the same meaning and content to all writers on this subject. When Macewen and others state that they have removed the periosteum in certain experiments they mean that part of the periosteum which is easily stripped from the shaft of the bone. But Mayer and Wehner and various histologists have shown that the cambium, or osteogenetic layer of the periosteum, which Macewen ignores or denies to exist, is applied so closely to the bone and so penetrates into the bony canals, particularly at the cancellous ends of the long bones, that it cannot all be removed even with a rasp. This fact must vitiate practically all such experiments unless it has been microscopically proved that there has been no osteogenetic layer of the periosteum left on the transplant.

Again, when Axhausen speaks of bone regeneration from marrow or medulla, he means regeneration from the endosteum which lines the marrow cavity and the Haversian canals. Like the periosteum this too cannot be completely stripped from the bone.

Likewise, there is some confusion in the use of the term bone graft. In some cases it means all the parts of a bone from periosteum to marrow, and again it means only the compact bony tissue, and frequently its meaning is not stated or indicated. When Gallie says a bone graft always dies, he is speaking of one probably without periosteum and with little or no endosteum.

In the second place the views of certain writers have been somewhat modified and we must consult their most recent utterances. Axhausen at first stated that bone regeneration occurs only from the periosteum, but he now maintains that the marrow, or endosteum, and joint cartilage are likewise transplantable, *i.e.,* they remain living and are capable of regeneration. Albee at first stated that a bone graft without periosteum is as good as one with it, but now he is careful to retain both periosteum and endosteum in the graft.

And, finally, most authors have disregarded Roux's law of functional adaptation. The final result of a bone transplanted into soft tissues where it bears no weight and serves no other function may be entirely different from that of a bone placed where it will serve a mechanical function. Function stimulates growth and regeneration both in normal and in transplanted tissues.

Let us now examine very briefly the various theories of bone transplantation. The old theory of Barth, recently restated by Murphy and others, that a bone transplant always dies and is absorbed and is replaced, if it be replaced, by bone from the recipient or contacting bone, must be definitely rejected. It is based on insufficient and defective evidence and is directly disproved by a large mass of experiment by Axhausen, Ollier, Albee, McWilliams, Nicholls, Phemister, Cotton and Loder, Hass, Lexer, Mayer and Wehner, Tomita, Trinci and others. In the experiments of the writer the transplanted bones did not contact with other bone except through their joint surfaces, which, of course, effectively prevent osteoconduction. The recent study of Gallie need not be considered as corroborative of the above theory, as it merely shows that some bone grafts without periosteum and with little or no endosteum may die and be replaced by bone from the recipient bone.

Macewen believes that the bone cells of the transplant occupying the lacunæ of the bony substance itself are the active agents in the life and regeneration of a transplant, and that the periosteum is only a limiting membrane and takes no part in osteogenesis. He makes the mistake of presenting no microscopical evidence and of entirely neglecting the consideration of the cambium layer of the periosteum. His experiments are all open to a misunderstanding because he does not exclude the possibility of bone formation from this structure, nor, moreover, from the endosteum and the lining of the Haversian canals. It would appear from the work of Axhausen, Phemister, McWilliams, Mayer and Wehner, and others that part of the bony substance of a transplant may live indefinitely although most of it soon dies, and it seems even possible that there may be regeneration from some of the bone cells which receive early and sufficient nutrition after the transplantation. Therefore, Macewen may have been partly correct in stating that the bony substance including Haversian canals lives and regenerates. But such regeneration must be far less than he supposed it to be, as it is now proved unquestionably that the preponderating part of regeneration is from the periosteum and the endosteum.

McWilliams' experiments show the great value of the periosteum to the life and regeneration of the graft, in that he records 100 per cent. of successful transplantations with the periosteum, against 48 per cent. without it; but he is content to ascribe this to the influence of the periosteum in maintaining the nutrition of the graft. He fails to recognize the importance of the cambium layer of the periosteum, although he states that periosteum transplanted into soft tissues may produce new bone. And his experiments with transplants free of periosteum are open to the same criticism as most similar experiments, that frequently all the osteogenetic layer is not removed. Nor is any mention made of the endosteum, although it seems to have been present in many or all of his cases. In my judgment his studies do not support the view of Macewen that the adult bone cells of the graft are the active element in its life and regeneration; and he directly contradicts him as to the importance of the periosteum.

The metaplasia theory of Baschkirzew and Petrow has already been discussed.

There remains a consideration of Axhausen's teachings and an attempt to arrive at a true understanding of what occurs after bone is transplanted.

Axhausen, in brief, states that transplanted bone cells at first remain unchanged during an indefinite stage, and that then some cells die while others continue to live. Eventually all bone cells die and the bony tissue is replaced by regeneration chiefly from the periosteum and secondarily from the marrow. Bone tissue histologically is not transplantable. Joint cartilage, however, is transplantable both histologically and clinically, and epiphyseal cartilage is to a limited degree clinically.

Axhausen's views appear, in the main, to be fairly correct according to a large number of observers, but probably he falls a little short of the truth.

I think it is no longer to be questioned that the inner, or osteogenetic, layer of the periosteum is of prime importance in the life and regeneration of a bone graft. Histologists have long taught that the periosteum is the main factor in the growth of the bone. Nicholls shows that periosteum will regenerate complete shafts of bones that have been destroyed or excised. Oechsner and others confirm this work. Ollier in 1859 showed that bone is regenerated from the periosteum chiefly and in smaller part from the cellular elements of the marrow and the Haversian canals. McWilliams says over reliance must be placed upon the periosteum.

Kass' experiments emphasize the value of this tissue and Lexer adds the weight of his authority in saying that the bony tissue of a transplant is gradually absorbed and is replaced by bone formed from the periosteum chiefly and from the medulla in part, and that the periosteum also aids in cementing the graft to the wound and in stimulating capillary invasion and early nutrition.

Joko produced new bone in six out of ten cases by injecting emulsion of periosteum of tibiæ of young dogs beneath the skin or into the muscles.

Trinci showed that transplanted periosteum is capable of early bone regeneration.

Tomita states that new growth is from the inner layer of the periosteum and from the marrow cells.

Phemister and Mayer and Wehner confirm the periosteal osteogenesis by very painstaking and thorough experiments. In all of Murphy's published cases the periostum was retained in whole or in part, although he states that the periosteum is not osteogenetic except when it carries osteoblasts on its inner surface.

If we view this entire process of the life and regeneration of a bone graft from the embryonal and histological point of view it seems very simple and reconciles the observations of many experimenters. The position of many of the bones is indicated in the embryo by the deposition of embryonal cartilage. But this cartilage is never directly converted into bone. It is replaced by bone formed from the osteogenetic layer of the periosteum. This layer sends bud-like extensions into the ossified centres, and proceeds to the formation of true bone. The lining of the marrow cavities, in other words the endosteum, the lining of the Haversian canals, and the external covering of the bone, the osteogenetic layer of the periosteum, are all one and the same thing. They are continuous at least for a time and have been derived from the periosteum. This internal and external lining is a connective tissue and its young cells are only specialized connective tissue cells called osteoblasts. All bone is formed through the agency of these cells. Some of them become imprisoned by the deposition of lime salts and separated from their fellows and they are then called bone cells. These are simply adult imprisoned osteoblasts.

The remaining bones of the skeleton that are not developed in embryonal cartilage are formed directly from the osteogenetic layer of the periosteum.

When the bones of the skeleton have attained their full growth the osteoblasts of the periosteum, the Haversian canals, and the endosteum cease their activity in large part. Piersol states that "after the cessation of peripheral growth and the completion of the investing layer of compact substance, the osteogenetic layer of the periosteum becomes more condensed and less rich in cellular elements, retaining, however, an intimate connection with the last-formed subjacent bone by means of the vascular processes of its tissue, which are in continuity with the marrow-tissue, within the intra-osseous canals.

"In addition to being the most important structure for the nutrition of the bone, on account of the blood-vessels which is supports, *the periosteum responds to demands for the production of new osseous tissue, whether for renewed growth or repair, and again becomes active as a bone forming tissue, its elements assuming the rôle of osteoblasts in imitation of their predecessors.*"

Does not this render the entire matter clear at once? Osteoblasts are present in the internal and external lining of bone and in the canals that partially connect these two linings which are thus essentially one and the same tissue. In adult bones these osteoblasts are reduced in number and are comparatively quiescent, but they are ready to respond to any demand made upon them for renewed growth or repair.

When a piece of bone or a whole bone is transplanted it is all temporarily deprived of its blood supply. But this does not necessarily mean the death of all the elements of the transplant. It would appear that in the transplantation of animal tissues the more highly specialized elements are less resistant to injury or deprivation of nourishment. Probably in bone the adult bone cell is less resistant than the young connective tissue cell, for example. Now as soon as the transplant is placed in its new position a process of re-vascularization commences. Those cells of the transplant which retain life until their source of

nutritive supply is reëstablished naturally can continue their life and function. Such cells probably are those which are the more resistant in themselves and which receive earliest a fresh supply of nutriment. This may reach them from the tissue juices that surround the transplant or from the blood-vessels that are reëstablished in it. The cells of the transplant lying near its surface therefore would have the best opportunity for maintaining life. And the smaller the transplant, the larger is its surface in relation to its mass, and the greater is the chance for the life cells in the transplant. Macewen's observations have confirmed this. Furthermore, the cells lying along the vascular channels would have a better chance than those lying in the lacunæ of the compact bone. And the very tissue that does line the outer and inner surfaces of the bone and the Haversian canals is the osteoblastic tissue, composed of young connective tissue cells, the osteoblasts, which are just waiting for the opportunity to exercise their especial function. The adult bone cells are imprisoned in hard compact bone and are doomed to death in large part. Even if some of them do survive and live for a long time, is it their function to form new bone to take the place of that which dies?

In practically every live bone transplant, therefore, there are osteoblasts, whether in the inner layer of the periosteum which closely lines the bone and sends numerous fingers into all the canals that open on the surface and which cannot be entirely removed by stripping off the periosteum macroscopically, or whether in the endosteum of the medulla, or whether in the Haversian canals, which are simply prolongations of the medulla. Many of these osteoblasts must be favorably situated to receive nutriment, and they stand as good a chance for the preservation of life and function as any transplanted tissues ever can. Therefore Macewen can strip off periosteum in whole or in part and the osteoblasts of the medula and Haversian canals will remain; Cotton and Loder can maintain the prime importance of endosteal proliferation; while Nicholls and Axhausen and many others can secure bone growth from the periosteum alone. But if the graft contains all three portions of osteoblastic tissue, its chances of life and development must surely be multiplied. Therefore McWilliams secures 100 per cent. of successes with the periosteum included, to only 48 per cent. without it. When Mayer and Wehner have rigidly excluded with metal caps the ingrowth of the periosteum on the surface of compact bone they have found no bone regeneration from the bone cells. Such adult bone cells probably are not capable of bone regeneration, they are no longer osteoblastic. But I am not sure that we should yet accept this statement as the final truth in all circumstances. Possibly even adult bone cells may revert to their original function under favorable or exceptional conditions.

And, finally, why need we adopt the metaplasia theory of Baschkirzew and Petrow when we have right at hand in the transplant live young connective tissue cells that have been formed and have for generations been accustomed to do just this one thing, regenerate bone.

McWilliams and Phemister in particular have dwelt upon the importance of an early and effective blood supply to the transplant. And the latter has well presented the importance of Roux's law in determining its ultimate fate. If it is in a position where bone is necessary to the welfare of the organism the transplant will survive and develop to a size necessary to its function. If it is in a useless position it will soon cease its growth and will probably be ultimately absorbed.

CONCLUSIONS

Certain conclusions which are of practical clinical value in surgery are readily drawn from the above experiments and discussion.

(1) Bone is only a particular form of connective tissue and is readily transplantable.

(2) It contains within itself all the elements necessary to its life, function, and regeneration provided it receives sufficient nourishment.

(3) Periosteum, medulla, and bony tissue should all be included in the graft.

(4) After transplantation the bone grows and moulds itself to perform its function efficiently.

(5) As early performance of function as is consistent with its fixation in its new position is of great advantage.

(6) A mild infection is not necessarily fatal to the graft.

(7) Transplantation of long bones with their joint surfaces is clinically possible. The inclusion of cartilage and joint surface in no way adds to the difficulty of the transplantation. While this statement is particularly true of the smaller bones, yet there seems to be no reason why as large a bone may not be transplanted with its joint surfaces as may be transplanted without such surfaces. Bier reports a large piece of tibia used to replace almost the entire shaft of the humerus, which has been under observation for 15 years. If a large bone should be transplanted it might be well to remove a portion of its shaft longitudinally in order to permit the ready access of a blood supply to the medulla.

Goebel reports the successful transplantation of the proximal phalanx of the second toe to replace the proximal phalanx of the fourth finger which was removed for enchondroma. Full motion finally resulted in all the joints of the finger. A piece of cartilage from a rib was used to replace the phalanx of the toe. The X-ray showed that at the time the case was reported the cartilage had not been transformed into bone.

Katzenstein reports the implantation of the phalanx of the great toe to replace the metacarpal bone of the thumb which was removed because of tuberculosis.

Galeazzi transplanted a metatarsal bone for a metacarpal which had been removed for neoplasm. There was good function after seven years.

Sievers also transplanted a phalanx to take the place of the middle phalanx of the ring finger removed for giant-celled sarcoma.

Wolff reports a successful similar case.

Lexer in 1907 transplanted a phalanx obtained from an amputated limb.

(8) Half joints are clinically transplantable. Lexer, Küttner, Rovsing, Wolff, Enderlen, Perthes, von Haberer, Walther, and De Gouvea, have reported successful cases.

(9) Whole joints have been successfully transplanted. Lexer has had under observation for six years a knee-joint in which motion and function are perfectly free and satisfactory, although the joint shows under the X-ray certain changes similar to those found in arthritis deformans.

Goebel and Eloesser have reported each a case of implantation of a toe-joint with unopened capsule to replace a finger-joint. A big difficulty in the transplantation of large joints is in the securing of suitable material. Lexer has discarded material obtained from the cadaver and now uses that obtained from freshly amputated limbs. Buchmann has transplanted the first metatarso-phalangeal articulation into the elbow-joint in two cases.

It has not yet been demonstrated, to my knowledge, that a small entire joint can be substituted for a larger one and grow in size to meet the necessities of the joint. It may be possible that the law of functional adaptation would apply even here.

In conclusion I wish to express my gratitude to Dr. J. E. Sweet for permission to carry out these experiments in the Laboratory of Surgical Research of the University of Pennsylvania and for many helpful suggestions in conducting them.

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Dr. Gwilym G. Davis thought that the question, whether or not the bone transplant is absorbed, is perhaps not of great importance. Some of Albee's work, and the work of others, have shown that if the bone is replaced it is replaced almost absolutely in the size and shape of the original bone as inserted. Therefore, whether it is replaced or not replaced, the effect is the same. Suppose if a person has a fracture in the shaft of a long bone, nobody would say that after healing either fragment had been entirely replaced by a new bone. Suppose a fracture occurs close to the articular end, as in Colles' fracture of the radius, does not the distal fragment live? In an osteotomy for hallux valgus back of the articular surface in which the bone is brought straight, does the head of the bone become absorbed and replaced? He hardly thought so. In one such case he took the head of the bone completely out, put it back, and closed up the wound. Healing occurred and the condition was as satisfactory as in the opposite side in which the head of the bone did not come out. Was the transplanted bone absorbed or not absorbed? Experiences like this are not rare even though one cannot positively explain the process from an academical point of view. The implant seems at least to retain its vitality and live very largely in the shape in which it has been implanted. Some of Albee's specimens are very marked illustrations of that. It seemed to him to be begging the question when one sees some of his transplantations of bone of the spine in which the implant is fused absolutely *in situ* and remains almost exactly as when implanted, to question the process. Of course, when a bone dies the death is more or less *en masse* and such grafts come away as sequestra.

NASAL OSTEOCHONDROMA

Dr. Nathan P. Stauffer presented a man, aged thirty years, who had been operated upon two years ago in the Jefferson Hospital for an obstructive growth in his nose. When first seen he had great pain in nose and was unable to breathe through either nostril.

A large hard mass protruded from the right nostril. It pressed the septum over, occluding right and left nostrils. Postnasally it could be seen extending to the uvula and appeared to be of connective tissue, well supplied with blood-vessels which easily bleed. X-ray report stated that the growth was in or extended into the right maxillary sinus. A tentative diagnosis of sarcoma of the nose was made and immediate operation advised. Operation refused and postponed on account of his wanting to keep a newly acquired job.

September 15, 1914, four months later, he returned with more pain in his nose and severe darting headaches and diminishing vision. Externally nasal bones were pushed out and the face much swollen. He was sent to the Presbyterian Hospital for operation, where on the following day he was anæsthetized by the Meltzer intratracheal method. The tracheal tube was lightly packed into the pharynx with two long strips of gauze to prevent inhalation of any blood *via* postnares and mouth, hæmostats were attached to these to keep them in place; the lips being elevated by a retractor, a labiogingival incision made, and the mucosa elevated to the inferior nares. He then cut through the inferior nasal mucosa from below and retracted the tissues but could not get around the growth. The incision was then enlarged by chiselling through the lower portion of the pyriform opening. The tumor was found apparently attached to the anterior end of the inferior turbinal bone. With the scissors this was severed and a large piece shelled out with a broad curette. The growth extended posteriorly, and piece by piece it was dissected from the mucosa of the right side. A large perforation was found in the septum and the growth filled the entire left naris, partially eroding the left maxillary antral wall. Finally with a finger in the postnares the rest of the mass was easily dislodged. Dr. Speese with the electric needle cauterized the inferior nares where it had been attached and the nose was irrigated with bichloride and packed with iodoform gauze. The labiogingival wound was stitched with catgut and the intratracheal apparatus and postnasal gauze were removed, as the anterior nasal packing was considered capable of controlling hemorrhage. His only bleeding came from the labiogingival wound, which was readily controlled by packing with a strip of one inch gauze. The subsequent convalescence presented no serious complication and he returned home at the end of two weeks. The pathologist reported the growth to be an osteochondroma.

Two months and a half later, December 12, 1914, renewed examination revealed a growth springing from the middle third of the inferior turbinal, possibly with a base in the maxillary antrum.

The operation succeeded in giving him good breathing space day and night, relieved his headaches, increased his vision and relieved his embarrassment while eating.

The question of recurrence is to be determined but the growth can be removed more readily now that it can be seen when first starting and as it is destructive apparently only by pressure this can be prevented by operating. The only other report of a case of nasal osteochondroma that he could find is by Dr. Robert Myles in the *Laryngoscope*, page 305, and is interesting in that he had to ligate the external carotid artery to control the hemorrhage.

CYSTADENOMA OF THE PANCREAS WITH EXTENSION TO THE ABDOMINAL WALL TEN YEARS AFTER DRAINAGE OF A PANCREATIC CYST

Dr. John J. Speese reported the history of a woman aged forty-nine years, who was first admitted to the Presbyterian Hospital in 1904, where she was operated upon by Dr. Duer for a large cyst of the pancreas.

The cyst wall was so adherent to the omentum and intestines, and the condition of the patient such that prolongation of the operation for the purposes of exploration was not warranted. The neck of the cyst was accordingly sutured to the abdominal wound and a considerable portion excised. The patient made an uninterrupted recovery, the sinus healing completely at the end of two months. Examination of the cyst contents showed pancreatic ferments; the histological examination of the cyst wall revealed fibrous tissue and no lining.

The patient was readmitted to Dr. Jopson's service on October 13, 1914, with a tumor of the abdominal wall which began three years ago as a small ulcer in the region of the umbilicus. Recently the growth has been rapid, measuring at present 5 cm. in diameter, and presents an ulcerated red surface, projecting slightly above the surrounding skin (Fig. 3). The edges are hard and indurated, the tumor is friable and bleeds easily, there is an offensive watery discharge which is non-irritative. The umbilicus is apparently involved in the tumor mass.

The growth was regarded as a primary carcinoma probably originating in the umbilicus, and was removed by a circular incision. The base of the tumor, however, was found to be attached to the abdominal organs by a definite pedicle, and on opening the abdomen, multiple small cysts were found, the small intestine and the transverse colon were so firmly adherent that it was impossible to explore the region of the pancreas or to do any form of radical operation other than removal of the superficial tumor from its pedicle. The wound was closed as in the Mayo operation for umbilical hernia, and a small drain inserted down to the stump of the pedicle. The patient made a slow convalescence, the sinuses gradually closing, but draining a small quantity of fluid when last seen, February 1, 1915.

The examination of the patient's stools showed no abnormality in digestion. The urine contained small amounts of albumen but no sugar. The quantity of fluid in the cysts removed with the tumor was too small to examine for ferments.

Pathological Examination.—The specimen consists of a tumor which is entirely surrounded by an intact area of skin. The mass projects 1 cm. above the level of the skin, is round in shape and measures 5 cm. in diameter and 3 cm. in thickness. The tumor is bright red in color, the surface presenting small areas of ulceration, and at its lower pole is partially covered with skin to which it is firmly attached, while at the upper margin there is a distinct furrow between the tumor and the skin. The base of the tumor contains a smooth glistening membrane (peritoneum) to which several masses resembling omentum are attached. A cross section shows that the mass is composed of tissue which is white in color, dense in consistency and contains numerous cysts varying in size from a pinhead to cavities 1 cm. in diameter. The cysts contain a colorless mucilaginous fluid, the walls are smooth in appearance.

On microscopic examination the sections show a process consisting of a dense connective tissue stroma in which are embedded glandular elements presenting various stages of activity. For the most part the acini are fairly large and present a very moderate degree of dilatation. In these acini and in the smaller cysts the lining is composed of high cylindrical epithelium containing many goblet cells, and the cysts are filled with a blue mucoid material containing desquamated cells. In many of the cysts the epithelium is greatly compressed and is flattened in appearance; in others it is thrown into folds by reason of fibrous ingrowth so that many minute papillary processes are present. Toward the superficial portion of the tumor the cystic nature is less marked and the acini more numerous. The slightly dilated glands are found immediately beneath the skin surface, the squamous lining of the latter has become broken and in some places is in direct apposition with the cells of the acini. In this area the stroma contains a round-cell infiltration and traces of blood pigment. Many blood-vessels are found in the stroma, but no evidence of normal pancreatic tissue can be found anywhere.

The diagnosis of a *proliferating cystadenoma of the pancreas* with extension to the abdominal wall at the point of drainage ten years previously, is based upon several factors. There can be little doubt concerning the original diagnosis of pancreatic cyst as ferments were found in the fluid. The findings at the second operation coincide with the picture frequently met with in such cases, and the histologic examination points to the same conclusions.

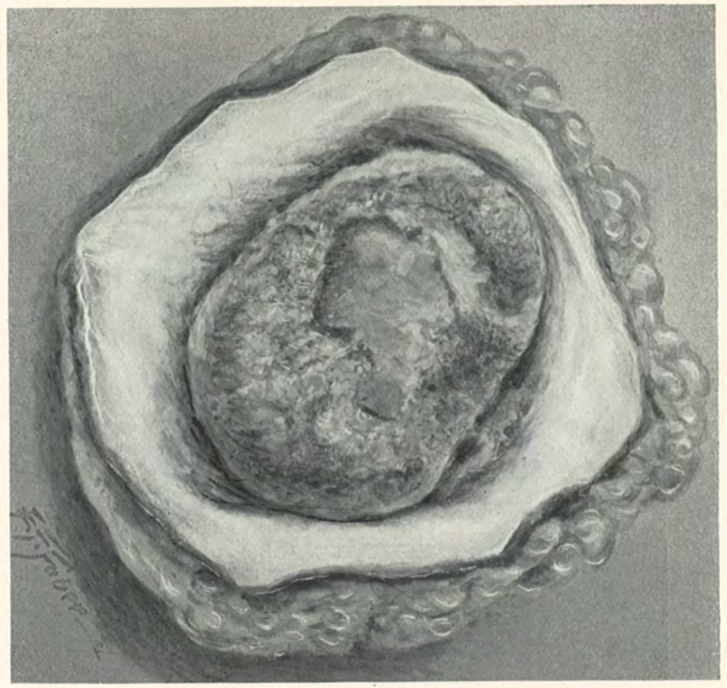

FIG. 3.—Cystadenoma of pancreas extending to abdominal wall.

FIG. 4.—Cyst of median nerve.

Of the many interesting facts brought out by a study of the case, emphasis can be made upon the very benign and comparatively mild course of the new growth, a fact noted by all writers on this subject. It would seem that drainage of the large cyst retarded further growth for many years, and doubtless many more would have elapsed without trouble if extension of the process had not been favored by the attachment of the large cyst to the abdominal wall. It is also noteworthy that sugar was not present in the urine during either stay in the hospital and that the growth had little or no effect upon the general health or nutrition of the patient.

CYST OF THE MEDIAN NERVE

Dr. Speese also related the history of a woman, aged sixty years, who struck her forearm two years ago in falling. She experienced very little pain from the injury, but noted shortly afterward that there was a distinct swelling above the wrist, and that this gradually enlarged but caused no discomfort. Three weeks ago she felt a sudden sharp pain in the forefinger, the pain radiating to the elbow. The severity of the pain has increased, becoming constant, at times interfering with sleep, and is unrelieved by any local or general measure. The patient asserts that the pain never arises in the tumor itself, always in the forefinger, radiates upward, and rarely is localized to the swelling in the wrist. She is able to use the fingers although motion causes some pain; there is no loss of sensation or atrophy of the hand. On examining the swelling, pain was caused by pressure over the tumor, which was oval in shape, three inches above the wrist and in the line of the median nerve. There is no pulsation, the enlargement presented the characteristics of a cystic formation.

The tumor was exposed under local anæsthesia, the slightest manipulation causing great pain until the median nerve was blocked by an injection of cocaine solution. The nerve above and below the cyst was exposed, at the upper pole the nerve fibres divided and many could be traced running over the external surface of the cyst from which they were dissected. The patient, a sufferer from a severe form of cardiac disease, insisted that the operation should afford permanent relief from pain and that she felt unable to undergo another operation. It was therefore necessary to divide the remaining fibres, and thus remove the cyst. The loss of nerve tissue was too great to approximate the cut ends, although there were several fibres uniting the nerve.

The patient was entirely relieved of the pain, the nerve fibres which were preserved evidently supplied the thumb, for sensation partially persists here, but sensation and motion are lost in the second and third fingers.

Pathological Examination.—Specimen consists of a round cystic tumor measuring 3.5 by 3 cm. The wall of the cyst is 4 mm. in thickness, is white and fibrous in consistency. At one pole of the cyst a section of nerve is seen from which small fibrils radiate and spread out over the external surface of the cyst. The cyst is filled with a blood-tinged fluid, its wall is smooth and contains traces of brownish pigment.

On microscopic examination the cyst wall is composed of two layers, the outer consisting of bundles of hyaline fibrous connective tissue containing comparatively few cells and a few blood-vessels. The inner portion or that which corresponds to the lining of the cyst is composed of a very cellular tissue, many new blood-vessels, a small amount of fibrous tissue and traces of blood pigment. The appearance resembles granulation tissue. Sections stained by Weigert's method do not reveal any nerve tissue in the inner portion of the cyst wall, but show remnants of nerve fibres attached to the external coat. The nerves are surrounded by a considerable amount of fibrous tissue and are the seat of degenerative changes.

The diagnosis of a blood cyst in the substance of the median nerve can be made from the above findings. This condition seems exceedingly uncommon as no mention of it is made in numerous text-books. It was unfortunate that the relief of pain was the chief indication for operation, as preservation of sensation and motion might have been maintained by less radical measures.

STATED MEETING, HELD MARCH 1, 1915

The President, Dr. John H. Gibbon, in the Chair

SPLENECTOMY FOR GUNSHOT WOUND

Dr. Thomas F. Mullen (by invitation) presented a colored man, twenty-eight years of age, who was brought to the Pennsylvania Hospital at midnight of January 6, 1915, one-half hour after having received a shot wound from a thirty-eight calibre revolver, in the hands of a man standing a few feet distant. The point of entrance was in the left mid-axillary line on a level with the tenth rib, which was comminuted. The patient was in profound shock, temperature 96°, pulse 160, respiration 48; the abdomen was diffusely tender and rigidity was marked, especially on the left side. On percussion, there was shifting dulness in both flanks. The abdomen was opened, beginning twenty minutes after admission; incision was made at the margin of the left rectus, and later enlarged by dividing the muscles transversely to the left, for a distance of three inches. Upon opening the peritoneum, there was a gush of dark fluid blood which, after packing off the intestine, was seen to be flowing from the region of the spleen. The spleen was grasped and lifted into the wound. It was found that the bullet had passed through the upper pole of the spleen, downward and backward, severing the vessels of the pedicle, which was clamped and ligated *en masse,* with catgut. Gauze drainage was instituted and the wound was hurriedly closed, as there was no apparent injury to any other structure. At the close of the operation, the pulse was imperceptible and twenty ounces of normal salt solution were given intravenously. The patient reacted quietly and vomited once during the following day. The drains were removed on the fourth day and the wound appeared to be clean. From this point his convalescence was uneventful, with the exception of a severe chill which occurred on the twenty-sixth day after operation, and was repeated on the twenty-eighth and thirtieth days. An examination of the blood at this time revealed, in fresh and stained specimens, many malarial organisms of the tertian type, and the symptoms promptly disappeared after the use of quinine. On the third day after operation, examination of the blood showed 48 per cent. hæmoglobin, 2,430,000 erythrocytes, 15,000