On the Power of the Periosteum to form New Bone. By JAMES SYME, Esq.,
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THE object of the following paper is to put at rest a question which has been long agitated in Surgical Pathology, and which is intimately connected with some important points of Practical Surgery. An apology may seem due to the Society for bringing under its consideration a subject, which, though not exclusively professional, is still little studied except by those physiologists whose views are directed to surgery; but as the inquiry into which I propose to enter is neither long nor tedious, while it is quite intelligible without any previous knowledge of its details, I trust the patience of the members will not be exhausted; and if the question shall, as I hope, be decided to the conviction of those members who are conversant with surgical discussions, the prevailing diversity of sentiment relative to the point at issue will be more effectually composed than if I attempted to combat it through any other channel.

The question which I propose to consider is, "Whether the Periosteum, or membrane that covers the surface of the bones, possesses the power of forming new osseous substance independently of any assistance from the bone itself?"

This property was first attributed to the periosteum by DUHAMEL, just 100 years ago. Having been engaged in the study of vegetable physiology, and more particularly the formation of wood, he imagined that there might be an analogy between the inner layer of the bark and the periosteum, and that as the former hardens in successive layers so as to constitute the wood, the latter might suffer a corresponding conversion into bone. He supported this opinion by the following arguments: 1. That when bones are burned in the fire or exposed to the weather, they separate into a number of thin plates. 2. That in consequence of disease arising from external violence, the bones frequently throw off thin scales, or exfoliations as they are called. 3. That when animals are fed alternately with madder and without it, their bones exhibit alternate layers of a red and white colour; and, 4. That when bones are fractured, they unite by means of an osseous capsule formed externally to, and embracing the broken extremities, just as the branch of a tree acquires strength after being grafted, or simply broken across.

This theory of DUHAMEL was strenuously opposed by HALLER, who urged, as altogether inconsistent with it, the mode in which bones are originally formed.

He carefully investigated the process of ossification during incubation, and detailed the steps of its progress in the chick as well as other young animals. The rudiment of the future bone being traced from its earliest distinguishable appearance, was found first to present the characters of a jelly; then to acquire the consistence of cartilage or gristle; and finally to reach the perfect osseous state: whence it was contended, that a structure which thus originated in a distinct form, and independently of any other, could not owe its increase afterwards to a different source. HALLER also engaged his pupils DETLEF and BOEHMER in extensive series of experiments, by breaking the bones of animals, and feeding them with madder during their recovery; from the results of which he inferred, that DUHAMEL had been mistaken in supposing that fractures are reunited by ossification of the periosteum.

Notwithstanding these objections, and the authority of the physiologist from whom they proceeded, the doctrine of DUHAMEL still maintained its ground; and not long afterwards, viz. in the year 1780, derived a great accession of strength from the experiments of TROJA, who, by destroying the marrow of bones, caused their death, and the formation of new shells surrounding them, apparently from ossification of the periosteum. This experiment, which TROJA himself performed some hundreds of times, when repeated and varied by the pathologists of almost every country, seemed to confirm the ossific power attributed to the periosteum beyond question, until SCARPA, the late distinguished Professor of Pavia, again investigated the grounds on which it was originally founded by DUHAMEL. In SCARPA's treatise "*De Penitiori Ossium Structura*," which was published in 1799, he explained, that the foliated appearance presented by bones that had been burnt did not depend upon the development of a structure naturally belonging to them, but was an effect produced by the unequal action of the fire; and that the separation of scales from diseased bones was no stronger proof of their possessing a laminated structure, since thin and broad portions of dead substance are wont to be detached from the skin and other soft textures, in which it was never supposed that layers existed naturally. He recalled attention to the synthetic experiments of HALLER, who, by investigating the formation of bone from the earliest stage to its perfect state, had established the reticulated nature of its texture; and by an opposite process of an analytic kind, which consisted in depriving bones of their earthy constituent by means of diluted acids, and then macerating them for a long while in water, he unravelled the texture so as to shew that it really was reticular. As a consequence of these observations, SCARPA denied that bone could be formed by the periosteum; and this opinion was keenly embraced by several pathologists of the present century, and particularly by the French surgeon LEVEILLE.

At present, professional opinion is divided in regard to the ossific power of

the periosteum, and different sides of the question are maintained by teachers and writers in this as well as other schools of medicine. As the point in dispute is not merely a matter of curiosity, but one of great practical importance, it is very desirable that the truth should be ascertained. It would detain the Society too long were I to shew how the different opinions on this subject may influence the practice of surgery; and I shall, therefore, proceed to state the considerations which have completely satisfied my own mind, and are, I think, sufficient to satisfy any one who is open to conviction, that though DUHAMEL was misled into many errors by the false analogy which he supposed to exist between wood and bone—in regard to the mode of their natural formation—the periosteum nevertheless does possess the power of producing new osseous substance in certain conditions of disease.

The well-known and often-repeated experiment of TROJA, which consisted in perforating the cavity and destroying the marrow of a bone, so as to kill it and cause the formation of a substitute in the form of a shell surrounding the old one, was devised in imitation of a process which not unfrequently occurs spontaneously in the human body. In this disease, which has been named Necrosis, a portion of the old bone dies, and becomes surrounded by a new one. There is an example of this on the table, in which the tibia, or principal bone of the leg, has been thus affected. The new shell is of a larger size and more irregular form than the old one, which may be seen through a number of circular apertures lying a prisoner within this structure, intended by Nature to serve as a substitute for it. Those who deny the ossific power of the periosteum, maintain that in all such cases, whether resulting from injury purposely inflicted with the view of experiment, or proceeding from diseased action, a portion of the old bone remains alive, and serves as the germ of a new one; that, in short, the formation of the new bone is simply an expansion or growth from the remnant of the old one, and that if merely the extremities of the bone affected remain alive, they will prove sufficient for generating the substitute shell.

It is difficult to reconcile this explanation with the rapid growth and uniform thickness of the new bone; since, if its formation proceeded from the extremities, the process should be slow and progressive towards the centre; but there is another objection still more conclusive against it. If the new bone is formed by a portion of the old one that remains alive, then the removal of a part by mechanical means should be supplied from the same source. But in all the cases where this has been done, either in the way of experiment or for the cure of disease, the loss of substance, unless of small extent, has been found imperfectly repaired. For instance, after the operation of trepanning the skull, the aperture in the bone, though it becomes diminished in extent, is not altogether obliterated, and the newly-formed bone is not only smaller than the portion removed, but also thinner, as may be seen from the specimens before me.

In the fore-legs of dogs and rabbits, there are two bones of nearly equal size, and so connected, that a large portion of one may be taken away without destroying the rigidity of the limb. There is here, therefore, a convenient opportunity of trying what can be done by the extremities of a bone for restoring losses of substance in its shaft. Experiments of this kind have accordingly been frequently performed on these animals, and the result has uniformly been, that when the portion removed exceeded an inch in length, there was a permanent deficiency of osseous substance, the ends of the bone being merely produced towards each other in a conical form, and connected together by a tough ligamentous texture. Sir A. COOPER has given representations of the results he met with; and on the table there is a specimen of my own experience (see Fig. 1, Plate IX).

Some of those pathologists who deny the ossific power of the periosteum, and claim the whole production of new osseous substance for the bone itself, have attempted to explain away the difficulties which have just been stated, by supposing, that in cases of necrosis where a new bone is formed, the old one, in consequence of the increased action preceding its death, may determine the effusion of organizable matter into the surrounding soft textures, which will serve as a matrix or foundation for the new shell, and be ready to take up the ossifying process so soon as it is communicated from the surviving extremities of the bone. That the process of reproduction may be accomplished in this way I am not prepared to deny, but that it is not necessarily, or always so performed, will, I think, appear from the following case.

A girl twelve years of age strained her ankle in the month of March 1835. Inflammation followed, extending up to the knee, and attended with violent fever. She was brought to the hospital, and placed under my care. Incisions were soon afterwards made to evacuate a large collection of matter which had formed in the leg. And the bone being found dead, while the patient's strength was rapidly giving way, I amputated the limb above the knee five weeks after the injury had been received. The girl recovered, and is now well. In examining the limb to ascertain the extent to which the bone had died, I found that it was partially surrounded by the commencement of a new one. This shell had already acquired considerable firmness at some parts, but was not equally thick throughout, and did not seem fixed to the ends of the old shaft. This observation led to a very careful dissection of the parts concerned; and they are now before the Society. It will be seen that the tibia had died very nearly from end to end, and that the new shell inclosing it has been formed in the periosteum. The new osseous substance may be observed at some parts in the form of small distinct scales. At other parts it looked as if it had originally consisted of separate portions, and been composed by their union. The periosteum connecting these portions to each other and to the extremities of the bone was not thickened beyond its natural

condition ; and where it covered the posterior surface of the tibia, though quite detached from the old bone, had not suffered any farther change.

There is here, then, an instance of a bone dying suddenly in consequence of acute inflammation, without any thickening having previously formed in its neighbourhood, and nevertheless succeeded by the production of a new osseous shell, which evidently could not proceed from the old bone, and no less evidently depended upon an ossific process resident in the periosteum.

As Nature is not capricious or variable in her proceedings, I regard this case as sufficient of itself, without any farther evidence, to establish the ossific power of the periosteum. But, with the view of making the matter still more clear, I performed the following experiments. I exposed the radius of a dog, and removed an inch and three-quarters of it together with the periosteum. At the same time I exposed the radius of the other leg, and removed a corresponding portion *without* the periosteum, which was carefully detached from it and left quite entire, except where slit open in front. Six weeks afterwards the dog was killed, and the bones examined. In the one from which a portion had been taken together with the periosteum, the extremities were found extended towards each other in a conical form, with a great deficiency of bone between them, and in its place merely a small band of tough ligamentous texture. In the other, where the periosteum had been allowed to remain, there was a compact mass of bone not only occupying the space left by the portion removed, but rather exceeding it (see Fig. II.). This experiment was repeated, and afforded the same results.

I next exposed the radius of another dog, and separated the periosteum from the bone as in the former experiment ; but then, instead of cutting out the denuded bone, inserted a thin plate of metal between it and the periosteum. The edges of the membrane, as well as those of the skin, were sewed together, and the wound healed kindly. At the end of six weeks I dissected the limb, and found a deposition of osseous substance in the periosteum, forming a bony plate exterior to the metal, and not connected with the old bone except by the membrane.

I lastly exposed the radius of a dog, and cut away the periosteum to the same extent that it had been merely detached in the experiment just mentioned, and surrounded the denuded bone with a piece of metal. At the end of six weeks, I found a thick tough capsule formed, enclosing the metallic plate, but having no osseous substance in it.

The evidence which has now been adduced seems to me sufficient for putting beyond all question the power of the periosteum to form new bone, independently of any assistance from the old one. I submit it, with deference, to the Society, in the hope, that those members who have directed their attention to the subject, will give it their dispassionate consideration, and either admit the opinion which it supports, or shew the fallacy by which it has misled.

EXPLANATION OF PLATE IX.

Fig. I. Radius of a dog from which a piece of bone was taken along with the Periosteum.

Fig. II. Radius of the same dog, from which a similar piece of bone was taken without the Periosteum.

Fig. III. Longitudinal Section of the last mentioned bone, to shew the solidity of the newly formed portion.

Fig. IV. Portion of bone which was removed in this experiment.