

# **Observations on the formation of bone by the periosteum / by Alexander Watson.**

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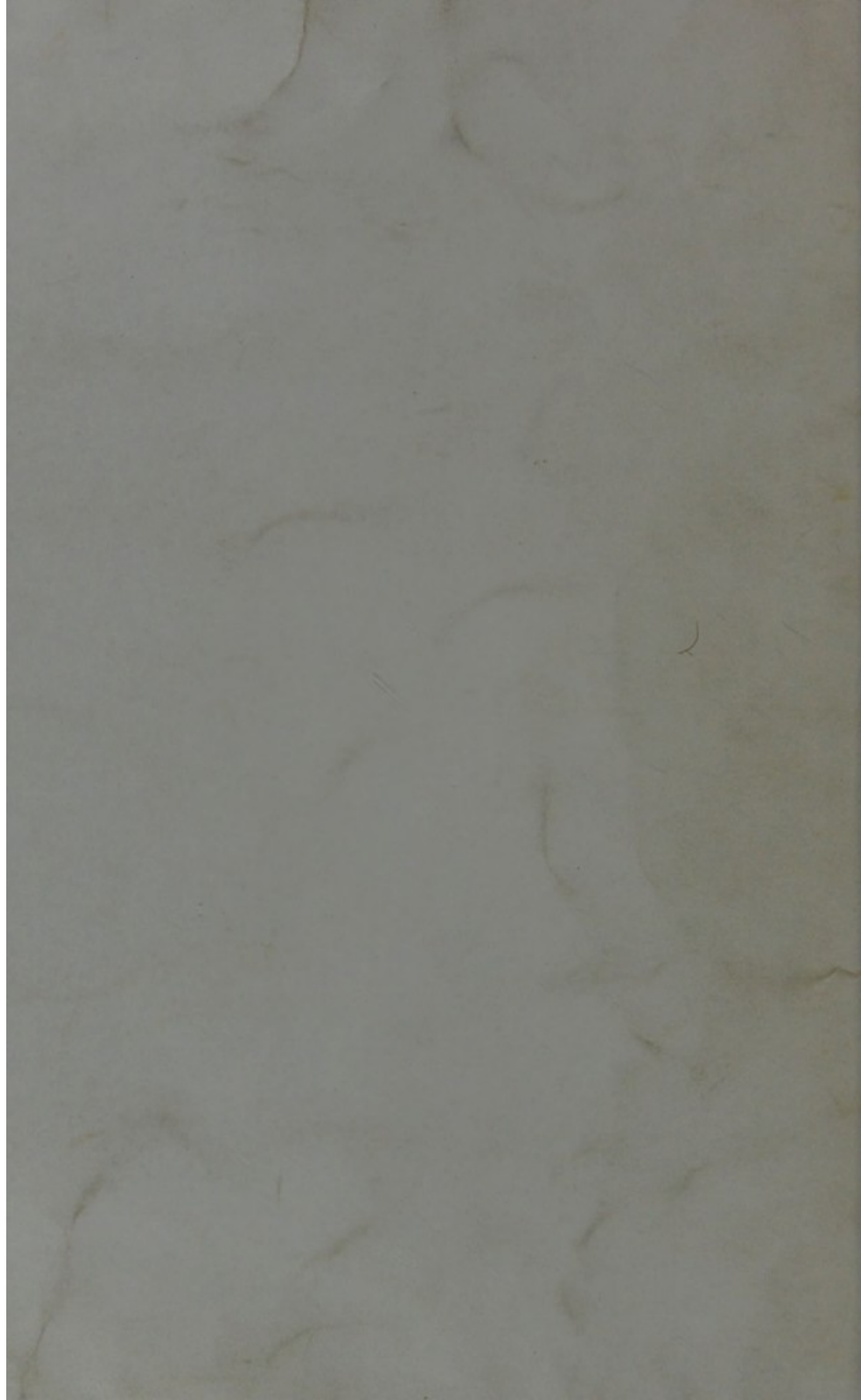
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*With compliments  
from the Author.*

*Observations on the Formation of Bone by the  
Periosteum.* By ALEXANDER WATSON, M.D., F.R.C.S.E.,  
Consulting Surgeon to the Royal Infirmary of Edinburgh, &c.

(From the *Edin. Med. and Surg. Journal*, No. 163.)

It was long believed that the periosteum not only conveyed nourishment to the bone which it enveloped, but also mainly, if not solely, contributed to the reproduction of bone, in cases of necrosis and fracture.

This opinion was founded on the observation of certain facts, which are certainly now to be considered rather limited and inconclusive.

In later times, however, the accuracy of this opinion has been called in question, and Professor Müller of Berlin says, that "the periosteum has nothing to do with the reproduction of the bone;" and he has denounced it as a "barbarism" in physiology to ascribe to the periosteum the capability of forming bone.\*

The followers of the German physiologists maintain the doctrine, which was also that of Sir C. Bell, "that bone only produces bone." In proof of this, they state, that the periosteum, having no such function, has therefore not the power to produce bone. They further state, in regard to the regeneration of bone,

\* Müller's Physiology, Trans. p. 383, and 427.



that, in cases of necrosis, minute portions of the old bone are separated from it before it becomes dead ; which, continuing adherent to the periosteum, retain their vitality, and form the nuclei from which the new bone originates and grows.

In consequence of these very opposite opinions on this subject, I have thought it worthy of further investigation ; and have therefore selected a few cases for the purpose of minute examination, such as I considered likely to contribute to the elucidation of the question at issue ; which, it will be observed, now seems to be, whether or not the periosteum has the capability or power to form new bone in cases of necrosis and fracture.

My attention in prosecuting this investigation was first directed to ascertain the correctness of the statement regarding the separation of portions from the surface of the old bone in cases of necrosis. For this purpose, therefore, I examined the following case, in which the reproductive process was in a very early stage.

CASE I.—*Of the formation of new bone in acute necrosis of the tibia.*—This occurred in a boy, 12 years of age, whose leg I amputated some weeks after the commencement of the disease. The periosteum was found to be thickened and separated from nearly the whole of the anterior part of the tibia, which had become dead.\* The exposed surface of the bone was smooth, except at a few points where there were irregular depressions or superficial ragged excavations, as if small portions of the bone had been corroded, (Plate II. Fig. 1.) From such excavations as these, it has been alleged that portions of the original bone have been separated ; and their vitality being preserved (as is supposed) by their continuing adherent to the periosteum, they become the nuclei by which the new bone is formed ; a process which would tend to support the theory, that bone only produces bone.

In order to ascertain the truth of this theory, I removed a portion from the inner surface of the periosteum, opposite to the largest of the depressions above described. Upon the surface of this portion of periosteum, the separated portions from the old bone should be found, which form the nuclei from which the new bone is developed. But a careful examination of this preparation, either with or without the microscope, shows that no such separated portions of bone exist. The inner surface of the periosteum was quite smooth and entire ; but at several parts of its texture after its inner surface was removed, there are minute portions of new bone of different sizes, which may be seen by the microscope, (Fig. 3.) At other parts of the periosteum, new bone is found in considerable masses, which are either covered on

\* See preparation in Royal College of Surgeons' Museum, No. 2228.



both sides by this membrane, or, having periosteum on one side, are adherent to that part of the old bone which had not become dead. These masses of new bone are formed by the new osseous deposits enlarging, and coalescing so as to form a spongy-like mass, (Fig. 4.)

This case, therefore, completely disproves two statements or theories which have been advanced, viz. 1st, That new bone is formed by portions of the old bone which remain alive, become detached from it, and continue adherent to the periosteum. 2d, That the periosteum does not of itself form bone. By a careful examination of this case, it is obvious that neither of these positions are verified, and consequently are incorrect.

CASE II.—*Of the formation of new bone after fracture of the femur.*—The subject of this case was a youth, 18 years of age, who received a fracture of his thigh bone near to the knee joint, for which he became a patient of the Royal Infirmary, under the care of Dr Handyside. Three months after the receipt of the injury, extensive suppurations formed, the extremity of the upper portion of the femur protruded, was in a dead state, and was undergoing the process of exfoliation. The state of the limb and of the patient's general health having rendered amputation necessary, I had an opportunity, through the kindness of Dr Handyside, of examining the state of the fractured extremities of the bone and of the periosteum connected with it. The only point, however, to which I have occasion to allude at present is, in regard to the origin and growth of the new bone formed at the situation of the fracture.

The broken extremities of the femur were surrounded by a mass of new bone, except at the part which had become dead and was exfoliating. This mass of new bone upon the upper extremity of the femur was from one to two inches in length, and nearly a quarter of an inch thick at some parts. Its surface was uneven, and was covered by a membrane externally, which consisted of a layer of the periosteum continued over it; while other layers of this membrane either formed part of its structure or passed underneath it. That part of the new bone next to the fracture, adhered firmly and intimately to the old bone by the indentation of spiculæ, without any membrane being interposed. The new bone gradually lessened in thickness as it receded from the fracture, till it consisted only of minute points of bone in the substance of the periosteum; while at the same time its adhesion was less intimate to the old bone, having a layer of the periosteum interposed.

The new bone, therefore, which surrounded the extremity of the old bone, when examined and traced downwards from the shaft of



the bone, seemed to be enclosed in the periosteal covering, which had been gradually expanded so as to increase in thickness towards the fracture, by the continued growth of the new bone.

On examining the periosteum about an inch above the commencement of the mass of new bone, numerous osseous points (visible only by being magnified by the microscope two or three hundred times), can be seen in the substance of the membrane after it has been split into layers, or cut into transverse sections, and rendered transparent by being dried.

Proceeding downwards, the bony points, becoming larger, are visible to the naked eye, (Fig. 6.) They also become more numerous, and, by increasing in size, coalesced so as to form spiculæ of new bone, having layers of the periosteum interposed.

The process which these facts reveal to us consists, *1st*, of increased thickness of the periosteum; *2dly*, of the deposition of minute points of osseous matter into its substance, by which it is separated into layers; *3dly*, of the gradual increase in the size of these osseous points till they coalesce, thereby compressing or causing the absorption of some of the layers of the periosteum; *4thly*, of the adhesion of the periosteum, loaded with osseous matter, to the old bone; *5thly*, of the gradual absorption of the inner layer of the periosteum, by the indentation of processes or spiculæ of the new bone into the old bone, by which they become incorporated.

All the points and masses of new bone are distinctly formed in the substance of the periosteum, not upon its surface. Their first appearance is that of a fine microscopic net-work, which gradually increases and assumes the texture of perfect bone. And, it is very remarkable, and very distinct in several of the preparations I have made, that these points of new bone are, in many parts, found close to the sides of blood-vessels.

From what has been said it will be obvious that this case, by coinciding so completely in its details with the preceding one, confirms completely the views there stated, as to bone being formed in the substance of the periosteum without assistance from the old bone by separated portions or otherwise.

CASE III.—In another case of fracture of the tibia and fibula, near to the ankle-joint, where the patient, (a man about thirty-five years of age,) died from erysipelas under my care in the Royal Infirmary, five or six weeks after the injury, I examined minutely the state of the periosteum, both of the fractured tibia and fibula.

In this case I found the periosteum at the fracture much thickened, by its texture being so filled with osseous matter, that it could scarcely be cut with a knife, (Figs. 2 and 5.) A thin vertical section of it, when dried, seemed to consist almost en-



tirely of bone, and was effecting the reunion of the fractured parts.\* The same appearances were observed in this which I have already described in the preceding case.

I might here adduce several other similar cases which I have examined, in proof and illustration of the observations I have made, but deem this quite unnecessary.

Before concluding this part of the subject, I may mention two or three other circumstances which are very remarkable. 1. When the broken extremities of a bone overlap each other, the formation of new bone takes place only at the parts required, being almost entirely on the sides of the broken bones, next each other, and even although they may be at a considerable distance apart. Two very remarkable examples of this are delineated in the plate, Figs. 7 and 8. 2. When a fracture takes place through the shaft of a bone extending into a joint, the formation of new bone stops where the periosteum terminates at the joint; an example of this, in the case of a fracture of the femur into the knee-joint, is now before me. Cases of this kind constitute negative evidence of the agency of the periosteum in the production of new bone. 3. In fractures of the neck of the femur, the peculiar structure of the periosteal membrane of the cervix and its laceration seem to be the chief causes of want of bony union.

*CASE IV.—Of the formation of new bone after the removal of a portion of the cranium by fracture.*—It has been asserted that, in cases of this kind, new bone is either not formed to fill up the chasm, or if it ever becomes occupied by new bone, this is formed by the gradual extension of the old bone from the sides of the aperture.

In the Pathological Museum at Vienna, under the charge of Professor Rokitanski, I lately had an opportunity of examining three specimens of fracture of the skull, with considerable apertures, caused by the removal of fractured portions of the bone. In these cases the patients had died, when the occupation of the apertures, by new bone, had been in progress, and was considerably advanced. In each of them a firm membrane occupied the opening; but whether this was the original periosteum or a new periosteal membrane, it is not easy to determine, from the preparations having been so carefully cleaned and dried. New bone also fills up the apertures to a considerable extent. This is evidently formed partly by extension from the old bone at the circumference of the aperture, and partly by ossification, obviously commencing at the centre of the membrane, by which it was at first occupied. I have in my possession a drawing from one of these cases, and minute portions of the new bone for microscopic examination, (Fig. 9.)

\* See preparation in Royal College of Surgeons, No. 2226.



From the foregoing observations the following inferences may be drawn:—

1. That the theories alleging that new bone is formed only by the living parts of the old bone, in cases of necrosis and fracture, are incorrect.

2. That the periosteum has evidently the power to produce new bone of itself, without the aid of the old bone.

3. That the formation of new bone by the periosteum consists, at first, in the deposition of osseous matter in the form of a fine microscopic net-work; and, therefore, that the Haversian canals are only a secondary, not a primary formation in osseous tissue.

4. That in cases of necrosis and fracture, the process of reproduction of bone by the periosteum is the same.

These observations were lately communicated to the Medico-Chirurgical Society of Edinburgh, and the preparations illustrating them were then exhibited.

#### *Explanation of Plate II.*

Fig. 1. Represents a portion of the tibia in a case of acute necrosis, showing the depressions which occur on its surface, probably from ulceration or absorption before it becomes dead. The portion of periosteum referred to above, and represented in Figs. 3 and 4, was removed from the part indicated at *a*.

Fig. 2. Portions of fractured tibia, from one side of the bone, referred to in Case III. *a*, *b*, and *c*, *d*, are the portions of broken bone; *e*, *c*, the periosteum of the upper portion thickened, filled with ossific matter, and connecting the broken fragments. The periosteum of the lower portion of bone is unchanged.

Fig. 3. Ossific points formed in the substance of the periosteum in case of acute necrosis, as seen by the microscope, and magnified 250 times. The ossifications, being opaque, look black in the field of the microscope, when examined by transmitted light.

Fig. 4. A portion of new bone from the same case, in which ossification is further advanced, magnified about 150 times. Here the ossifications have coalesced, so as to form a spongy-like mass.

Fig. 5. Ossific points as seen in a thin vertical section of the periosteum in case of fractured tibia, at a part selected for being least advanced, magnified 150 times.

Fig. 6. Ossific points in periosteum of their natural size, from cases of fracture of the femur. In order to be seen, the periosteum was split into two layers, and rendered transparent by being dried on a piece of glass. The extremity marked by the letter *a* is the layer which was next to the bone, *b* the external layer.

Figs. 7 and 8. Two irregularly united thigh bones, in which the new osseous matter has been deposited only on the sides when it was required to form the union. From the Hunterian Museum, Glasgow.

Fig. 9. Aperture in cranium occupied by membrane, in the centre of which new bone is formed.

51, Queen Street,  
Edinburgh, January 1845.



