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DIRECT MEDULLARY-TO-PERIOSTEAL TRANSITION AND THE OCCURRENCE OF SUBPERIOSTEAL HAEMATOPOIETIC ISLANDS

D. H. Enlow
Department of Anatomy, The University of Michigan, Ann Arbor, Michigan, U.S.A.

During the growth and remodelling of bone, a direct conversion between medullary or endosteal connective tissues and periosteum takes place in some parts of the bone. An intervening layer of cortical bone is not involved. A converse process of periosteal conversion directly into medullary connective tissue can also occur without an intermediate stage of ossification.

The basis for this previously unreported situation lies in normal remodelling changes which take place during bone growth. It is known that young, rapidly growing bones are partially composed of a particular variety of bone tissue which is non-lamellar and which has a fine-cancellous texture. This is in contrast to the compact, lamellar structure of most adult bone tissues (Rouiller, 1956; Smith, 1960; Enlow, 1963). During the growth of a bone, the cortex is continually moving in a variety of inward and outward (endosteal and periosteal) directions during the complex remodelling sequence which accompanies growth. Outward cortical movement is a result of subperiosteal deposition of new bone together with resorptive removal from the endosteal surface. Conversely, the inward (endosteal) movement of the cortex is brought about by periosteal resorption together with endosteal deposition. Because of the cancellous nature of this young, rapidly growing bone tissue, a direct contact between medullary connective tissues and the periosteum occurs in those areas occupied by the relatively large cancellous spaces (Fig. 1). This contact line is itself in continuous movement in either periosteal or endosteal directions as the entire cortex moves in a corresponding outward or inward course. As a result, continual changes in the structure of both endosteal and periosteal connective tissues take place as one becomes altered into the other. During inward growth, the reticular connective tissue of the medulla undergoes direct fibrous and cellular transformation into the collagenous connective tissue of the periosteum. Reversals in direction of growth commonly occur during successive growth stages so that this transformation process becomes reversed. The collagenous connective tissue of the periosteum is then converted into reticular medullary tissue. The continuously moving line of separation between endosteum and periosteum is well defined and readily identifiable using routine staining methods for collagenous or argyrophilic tissues. Direct fibrous transitions may be observed, and abrupt changes in the cellular components of the tissues are seen.

The nature and structure of medullary connective tissue varies according to age and location in the young growing bone. An undifferentiated (primitive) tissue type can

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be present, or tissues in medullary or cancellous spaces may be haematopoietic. A thick or well-defined endosteum as such does not exist, and periosteal-to-endosteal changes involve transformation almost directly into or from a basic reticular (argyrophilic) connective tissue. Since medullary tissue may contain myeloid elements, an interesting situation is encountered in which haematopoietic tissues become translocated, by an inward shift of the cortex, over onto the periosteal side of the bone (Fig. 2). During this cortical shift, the fine-cancellous spaces of the cortex are exposed on their periosteal sides as periosteal resorption and endosteal deposition bring about a movement of the cortex in an endosteal direction. Such haematopoietic islands are seen just beneath the periosteum at the endosteal-periosteal contact. An intervening plate of cortical bone, in the area of a cancellous space, is not present. Small surviving masses of such myeloid tissue are sometimes found in the periosteum itself as this membrane continues to move in a progressive endosteal direction. The fate of these periosteal haematopoietic remnants is not known.

Mechanisms of structural and molecular transformations between reticular, precollagenous, and collagenous fibres as well as between the specific cell types associated with them, are currently receiving a great deal of attention. It is suggested that the tissue transitions described here can be utilized by workers using histochemical, electron microscopic, and radioisotope methods in detailed studies of connective tissue growth.

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PLATE 1

FIG. 1. The fine-cancellous trabeculae in this section are located directly beneath the periosteum. An intervening layer of subperiosteal bone is not present. The medullary spaces between these trabeculae have become exposed to the periosteum as bone growth proceeded in an endosteal direction. Medullary and periosteal tissues are in direct contact, and as the cortex moved in a continual endosteal direction during remodelling, conversion from reticular to collagenous connective tissue has taken place. In the zone of endosteal-periosteal transition, note the presence of very dark fibrils, stained with colloidal iron, which represent a structural transition between argyrophilic and collagenous fibres. Human rib, mid-term foetus, PAS and colloidal iron. × 100.

FIG. 2. This area of the metaphysis has received periosteal resorption as its dia. becomes reduced in an endosteal direction. The medullary spaces between the fine-cancellous endochondral trabeculae have been uncovered, and medullary soft tissues are in direct contact with the periosteum. Note that myeloid tissue now occurs directly beneath the periosteum without intervening cortical bone. Neonatal human femur, haematoxylin and eosin. × 100.

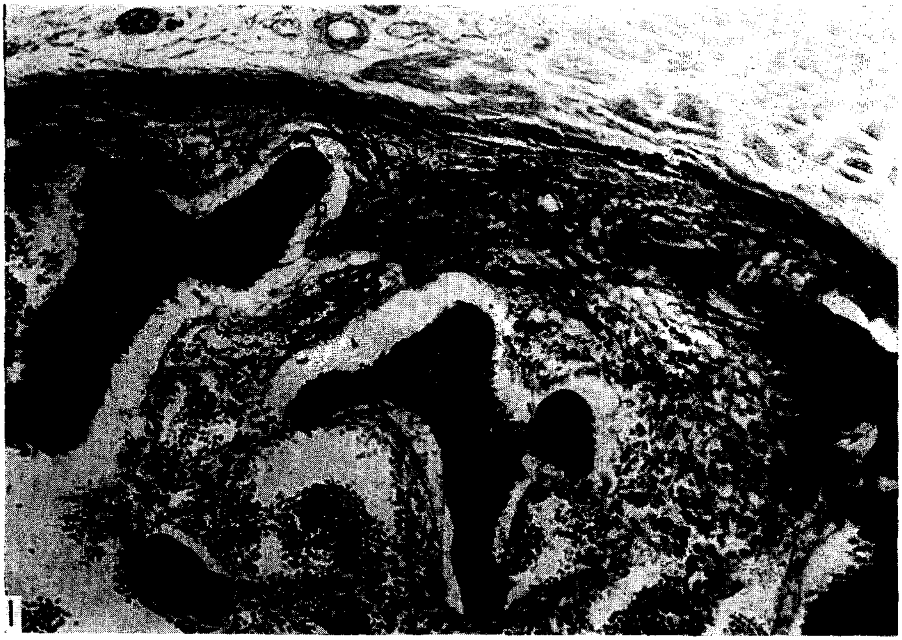

PLATE 1