

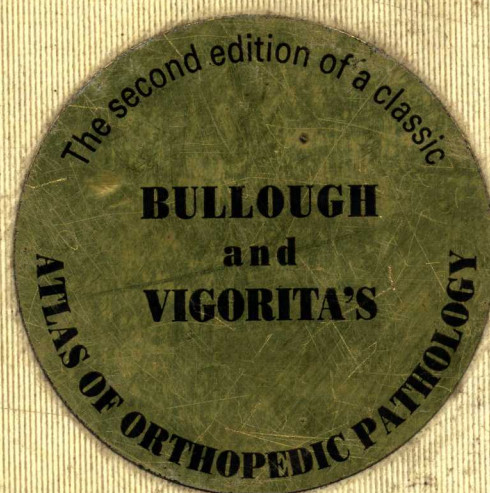


Atlas of

Orthopedic Pathology

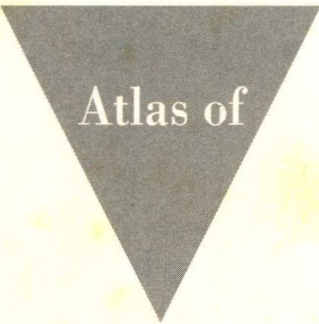
with Clinical and Radiologic Correlations

2nd edition



PETER G. BULLOUGH


Forewords by:
Lauren V. Ackerman
Philip D. Wilson Jr.



Atlas of

Orthopedic Pathology

with Clinical and Radiologic Correlations



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Atlas of

Orthopedic Pathology

with Clinical and Radiologic Correlations

2nd edition

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D E D I C A T I O N

**To the memory of my
Mother and Father,**

*And many more, whose names on
Earth are dark,
But whose transmitted effluence can
not die,
So long as fire outlives the
parent spark.*

—Percy Bysshe Shelley

F O R E W O R D S

This book was first published in 1984, and it is now time for a new edition. The present volume has been completely revised, its contents rearranged, and the text expanded by a third, with five new chapters. There are 350 additional illustrations.

This is an elegant book. Textbooks are often marked by complicated prose, poor grammar, and faulty syntax. The present volume is a wonderful exception, a pleasure to read, for each sentence has been constructed with care and each sentence adds information that is directly relevant to the subject. The text is not cluttered with references and numbers but at the end of the book there is a carefully selected current set of references corresponding to each section. This appendix will serve readers interested in expanding their knowledge without being obliged to decide among 300 references on a given subject.

Although the title indicates an atlas, this book goes far beyond that category, including an extensive discourse on arthritis, and other areas such as metabolic bone disease and rare entities. To substitute adequately for Bullough's work one would have to buy a book on metabolic bone disease, another on arthritis, and a third on neoplasms. The thorough presentation of arthritis is alone worth the price of the book.

Another unique feature of the text is the presence of line drawings accompanying illustrations such as gross photographs, photomicrographs, x-rays, and electron microscopy. Each of these illustrations was chosen to provide a visual representation of a particular bit of information.

Although the book has been discovered by orthopedic surgeons, pathologists have not as yet realized its value, since many pathologists are afraid to look at a piece of bone. This book will soothe their fears and open up an area of knowledge in which many are deficient. It has been a rewarding pleasure for me to read the new edition and I recommend it to you with the greatest confidence.

Lauren V. Ackerman, M.D.
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This new edition of Peter Bullough's *Atlas of Orthopedic Pathology* has been entirely reorganized, updated, and enlarged into 19 chapters. Along with new information, most of the previous text has been rewritten. As with the first edition, a correlated slide atlas is available and extends the suitability of the material's use for study, lectures, and seminars.

The illustrations are superb, the supporting text and legends comprehensive, clear, and concise. Specific points in the photographs are highlighted and clarified by accompanying line drawings. The resulting presentation is not only informative but beautiful to behold. To review the book's pages is a pleasing experience.

In the seven years since the first edition, there have been many advances in orthopedic and rheumatologic knowledge and understanding, and new data and practices have been worked into the second edition. The material is sensibly organized into six major sections: *Normal*, which includes structure and examination methods; *Response to Exogenous Injury*, including infections; *Metabolic Disturbances*, which includes congenital and developmental chondro-osseous dystrophies, "aging" conditions of bone, mineral metabolic and endocrine changes, marrow storage diseases, and hematologic disorders; *Arthritis*, with special chapters on spondyloarthropathies and tissue responses to implanted material; *Tumors*, with four separate chapters; and *Common but Unexciting Orthopedic Conditions* in two chapters.

The clinical significance and applications of the pathologic information are highlighted, making this an essential text for all orthopedists, rheumatologists, and radiologists as well as pathologists, whether generalist or specialist oriented. Also, all those who want to acquire or maintain a broad knowledge base in musculoskeletal pathology and its clinical correlations will find this book to be an important resource. It is useful, therefore, to student and teacher alike. At this point in time when maintenance of competence through continuing education is being emphasized, and even demanded, I cannot think of a better method for doing so than by a thorough study of this atlas.

Dr. Bullough is to be complimented for his exhaustive labor in revising and expanding this edition, which reaffirms the atlas's position as a masterpiece in the field of orthopedic literature. Gower is to be thanked for making the resulting volume available to us in such a beautiful form.

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P R E F A C E

Musculoskeletal conditions are the third most frequent cause of acute disease resulting in a visit to a doctor, the fifth most frequent cause of hospitalization, and the third most frequent cause of surgery. They impact principally on the quality of life, with the elderly suffering the most, usually from arthritis and osteoporosis. Unfortunately, medical school curricula and most pathology training programs assign disproportionately little time for the study of bones and joints. At autopsy, attention is given to the study of parenchymal organs, rather than to the study of bones and joints. A great deal of pathology is being overlooked as a result.

From Virchow's time to the present, there have been students for whom musculoskeletal diseases have held a particular interest, and a few excellent texts have been written on the pathology of bones and joints. When this book was first published in 1984, the intention was to provide a concise, yet lavishly illustrated and comprehensive, account of the pathology of musculoskeletal diseases. In the process, we hoped to stimulate interest and enthusiasm for this important branch of pathology.

In this new edition, the text has been completely revised and is now 50% longer. Five new chapters have been added as well as 363 new figures. However, the object remains the same, to provide an up-to-date and concise account of bone and joint disease.

This book has been written for the use of busy practicing surgical pathologists as well as for orthopedic surgeons who would like to better understand their subject. Radiologists having a special interest in skeletal radiology will also find this book helpful. For orthopedic surgeons and radiologists, chapters on normal bone and on histologic preparation of bone have been included, as has a chapter describing the histologic processes involved in injury and repair in general, and of the connective tissues in particular. These chapters provide background information for the pathologic descriptions that follow.

The clinician visualizes the morbid anatomic changes associated with disease by various imaging techniques, which figure extensively throughout the book. Line drawings are used liberally to indicate specific features in a photograph. Where the three-dimensional and/or temporal aspects of structure must be communicated, color schematic and anatomic drawings are provided.

The bibliography is arranged by chapter, and then fur-

ther divided by condition. The references per condition have been chosen to best amplify the presentations in this book and to provide further access to the literature.

Most of the gross photographs and photomicrographs used were taken over the many years of my professional life: first, as a fellow at the Hospital for Joint Diseases in New York; next, as a lecturer in orthopedics at the Nuffield Orthopaedic Center in Oxford, England; and finally, over the past 22 years, as a pathologist at The Hospital for Special Surgery in New York. Most of the clinical radiographs are from the radiology department at The Hospital for Special Surgery and are used with the kind permission of Dr. Robert Freiburger and Dr. Jeremy Kaye. Additional illustrations have been generously contributed by numerous colleagues throughout the world, to whom I am extremely grateful.

Our interest and understanding depends upon our teachers and upon our students, but perhaps even more importantly upon our colleagues, and I feel myself extremely fortunate in having had so many stimulating and helpful colleagues. I am most particularly grateful to the members of the New York Bone Club, who have met together once a month for the past 12 years and have shared their experience and their knowledge. From this exceptional group I have learned more of my profession than from any other source.

In the preparation of the first edition of this book, I was fortunate to have the assistance of Dr. Vincent Vigorita who had just completed his fellowship at Memorial Hospital before joining our staff as assistant pathologist. For this edition, I have had the invaluable help of Dr. Rafael Castro, who has been with the pathology department for the last two years. Through his organizational skills he managed the logistics of cataloging illustrations, checking the references, tracking down radiographs, and many, many other tasks which are entailed in such a project as this. I am extremely grateful to him for all his help and support.

I am also indebted to the staff of the pathology department at The Hospital for Special Surgery—both past and present—for their excellent work in this and other projects over the years. Finally, I thank the staff of Gower Medical Publishing for the care that went into the preparation of this book: to Sharon Rule and Jane Hunter for their editing, to Surachara Wirojratana for her satisfying design, and to Abe Krieger for his keen interest and unflagging support throughout.

Peter G. Bullough

S E C T I O N I

NORMAL

The explanation of disease, *pathology*, from the Greek Πάθος (suffering, disease) and λογος (reason, discourse), has always been central to the practice of medicine. In Western medicine throughout the nineteenth and twentieth centuries, the explanation of disease has been based on the scientific observation of departure from normal anatomy to morbid anatomy (Morgagni 1761), from normal tissue (histology) to disturbed tissue (Bichat 1800), from normal cell structure to abnormal cell structure (Virchow 1858), and at each of these levels from normal function (physiology) to abnormal function (pathophysiology).

Acute disease, a subjective state, is the result of acute malfunction, malfunction being in general the conse-

quence of mechanical trauma, infection or metabolic injury. In any tissue, acute disease may become chronic either as the result of continuing injury, or as the consequence of ineffective or imperfect repair.

In the connective tissues, acute injury may lead to profound and immediate malfunction. Fracture of bone and rupture of a ligament are examples. In the connective tissues in particular, the processes of repair will restore normal function only if they first restore the normal anatomy.

The recognition of normal anatomy, normal histology, and normal cytology, together with an understanding of function at each of these levels, is thus essential to the recognition and understanding of disease processes.

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C H A P T E R 1

**Normal bone structure
and development**

The microscopic examination of bone dates back to the earliest days of microscopy. In 1674, Anton van Leeuwenhoek read a letter to the Royal Society on the topic; soon afterwards, in 1691, Clopton Havers published his *Osteologia Nova*, in which he described the pores in the cortical bone to which we now refer as haversian canals. Since then, major contributions to the study of bone anatomy and histology have been made by many of the most famous names in pathology and medicine. To name but a few, Cheselden, in 1733, wrote the *Osteographia*, which contained full and accurate descriptions of all human bones gained with the use of the camera obscura; the beautiful and accurate work of Albinus on bone and muscle, in 1754, estab-

lished a new standard in anatomical illustrations; the experiments of Haller in 1763 contributed greatly to the understanding of bone formation; Hunter, in 1772, did much to elucidate the mechanism of bone growth, particularly the appositional mechanism rather than that of interstitial growth such as occurs in other organ systems; Winslow's *Anatomical Exposition*, in 1776, systematized the approach to bone anatomy; Bichat, in the early 1800s, stressed the importance of the tissue elements shared among the different organ systems (hence histology) and, in particular, described the synovial membrane; and Virchow, in the latter half of the nineteenth century, wrote classic descriptions of several bone tumors and metabolic disturbances.

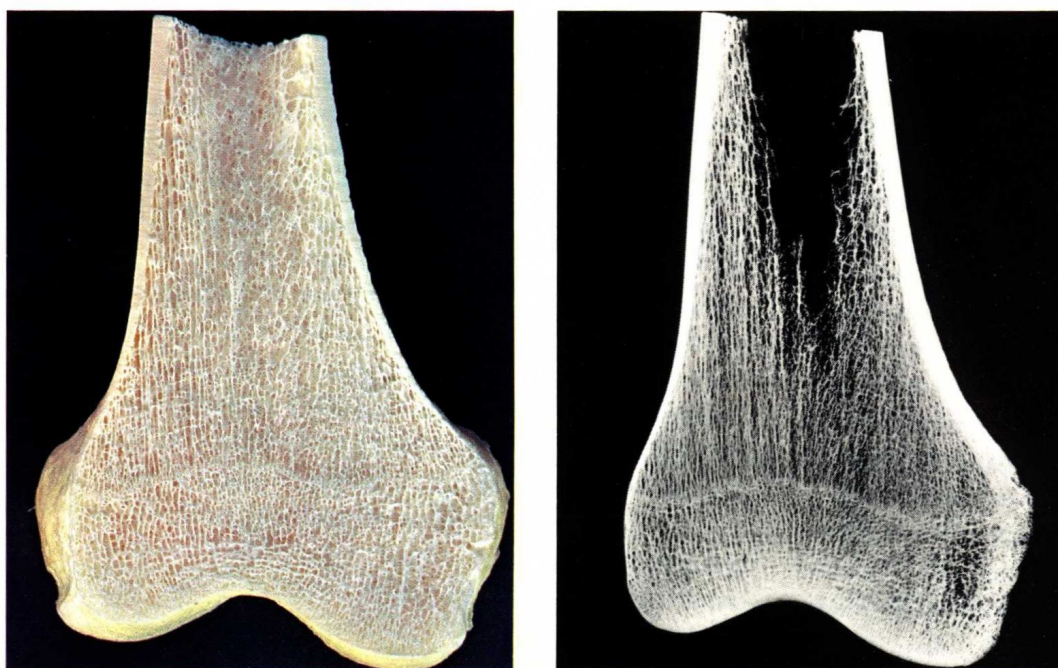


FIGURE 1.1 Cleaned and macerated specimen of lower femur demonstrates the distribution of cancellous bone and the thickening of the cortex approaching the diaphysis (left). Radiograph of the same specimen (right). Note the horizontal plate of bone which marks the site of the previous cartilage growth plate (the "epiphyseal scar").

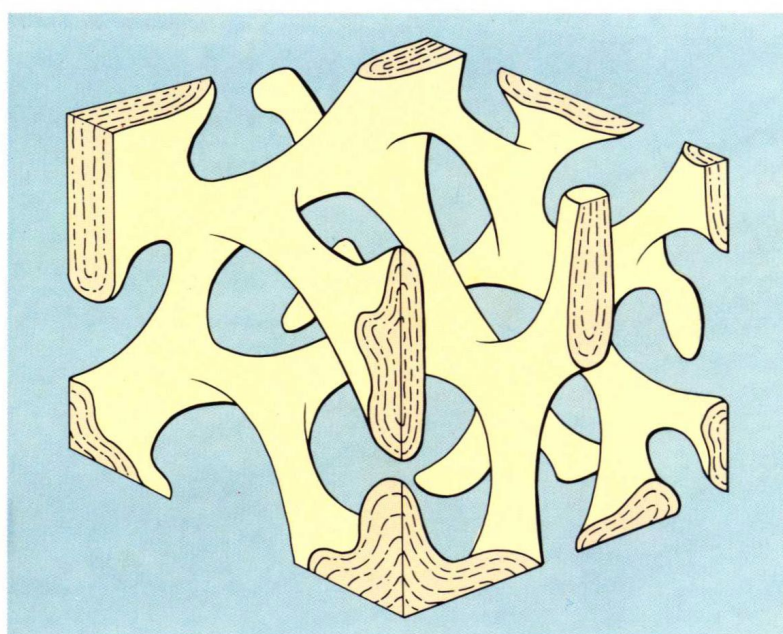


FIGURE 1.2 (left) Scanning electron micrograph (x 400), and (right) schematic representation, of the plates and rods of bone in the cancellous bone.

Bone, cartilage, ligaments, and tendons have a primarily mechanical function: they provide movement, support, and protection. Unlike the parenchymal organs, eg, the liver or kidneys, which are composed mainly of cellular elements with a metabolic function, the connective tissues are formed mostly of an extracellular material (or matrix) made up of substances (both fibrous materials and packing materials) well-suited for the mechanical functions of those tissues.

THE BONES

GROSS STRUCTURE AND FUNCTION

Each bone has a limiting surface shell known as the cortex. Enclosed by the cortical shell are plates and rods of bone tissue known as the spongy, cancellous, or trabecular bone (Figs. 1.1 and 1.2).

Cortex thickness varies considerably, both within a single bone and among different bones. For example, in

normal vertebral bodies the cortex is very thin, whereas in long bones, such as the femur and the tibia, the cortex in the mid-diaphysis may reach more than a quarter inch in thickness. Even in the long bones, however, there is great variation in thickness between the ends of the bone (in which the cortex is thin) and the midshaft of the bone (in which the cortex is thick).

A moment's reflection will make the reason for these differences obvious. The thick cortical bone is well constructed to resist bending, and it is in the middle of the long bones that this force occurs. In contrast, the cancellous or trabecular bone is concentrated where compressive forces predominate, ie, in the vertebral bodies and in the expanded ends of long bones. Thus, the architecture of the bone reflects its function. This concept of an organized distribution of structural elements is summarized in Wolff's law, which can be simply stated as: "Every change in the function of a bone is followed by certain definite changes in internal architecture and external conformation in accordance with mathematical laws" (Fig. 1.3).

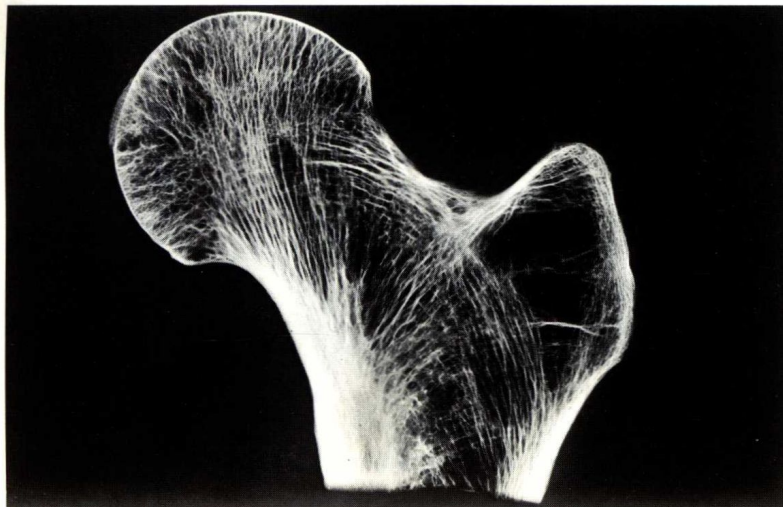
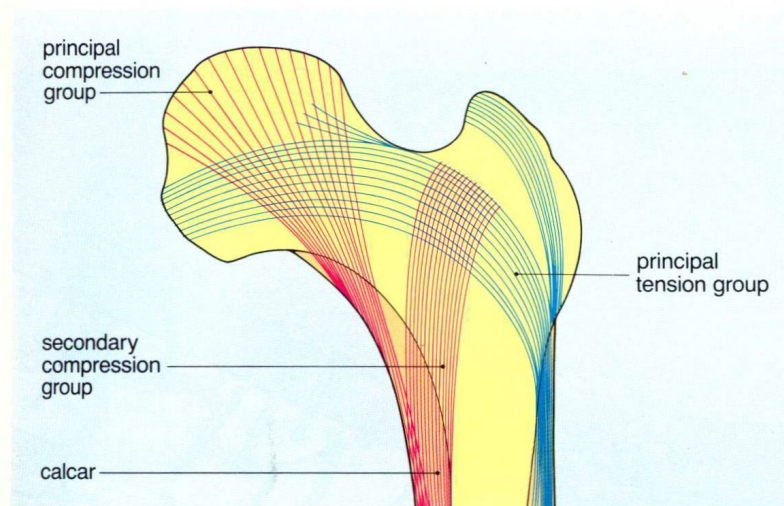


FIGURE 1.3 (*upper left*) Wolff's law is well demonstrated in the head and neck of the femur, in which the bone trabeculae radiate from the articular surface down onto the medial cortex of the femoral neck (the calcar), which is much thicker than the cortex on the lateral side of the femoral neck. (*upper right*) In this slice through the upper end of the femur, the marrow fat has been washed out of the specimen to better demonstrate the distribution of the cancellous bone. (*lower left*) The best way to demonstrate the arrangement of the bone trabeculae is by radiographs of the specimen.

As we shall see shortly, the arrangement of the elements of the extracellular matrix, both in the bone itself and in all other connective tissues—eg, cartilage, tendon, meniscus, intervertebral disc—is also no less precisely organized for its mechanical function.

The bones are often compartmentalized by the morphologist into three indistinct zones: the bone end or epiphysis—the region above the growth plate (or, in adults, the zone above the closed growth plate); the metaphysis—the region immediately below the growth plate (in the growing animal, the area of growth and most active modeling); and the diaphysis—the region between the metaphyses (ie, the shaft of the long bones). The terms epiphysis, metaphysis, and diaphysis are useful in the description of disease, because many diseases have predilections for one or another of these compartments (Fig. 1.4).

Periosteum

Except at the musculotendinous insertions and at their articular ends, the bones are covered by a thin but tough fibrous membrane, the periosteum. At the

articular margins and tendinous insertions the periosteum blends imperceptibly with the surface fibers of those tissues.

The periosteum is attached to the surface of the bone cortex by collagen fibers (the fibers of Sharpey) which are direct continuations of periosteal fibers. Where these fibers enter the bone they are encrusted with hydroxyapatite, which cements them into the bone (Fig. 1.5). Therefore, any attempt at separation of the periosteum from the bone requires physical tearing of these fibers.

On microscopic examination, the periosteum is seen to have two layers: an outer fibrous layer and an inner cambium layer, which forms bone. In children the cambium layer provides for the increasing diameter of the bone with growth (Fig. 1.6). In adults, the bone-forming potential of the periosteum is reactivated by trauma and infection, and in association with some tumors. In children, the periosteum is only loosely attached to the underlying bone, whereas in adults it is firmly attached. Thus the clinical extent of periosteal reaction, which in similar conditions is much greater in children than in adults (Fig. 1.7).

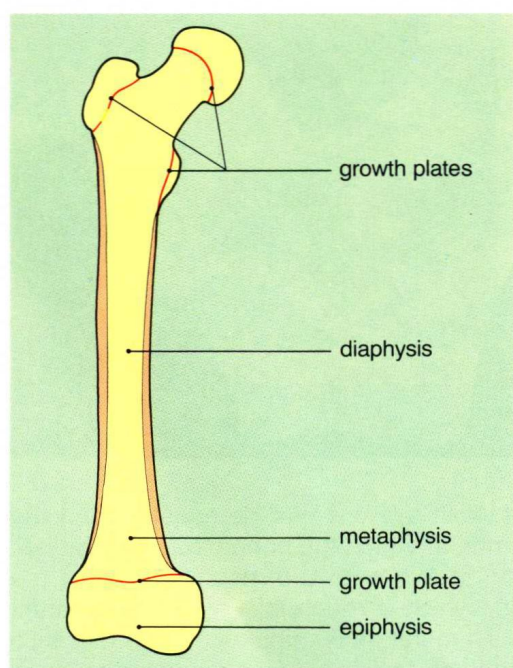


FIGURE 1.4 Bone compartments in the femur.

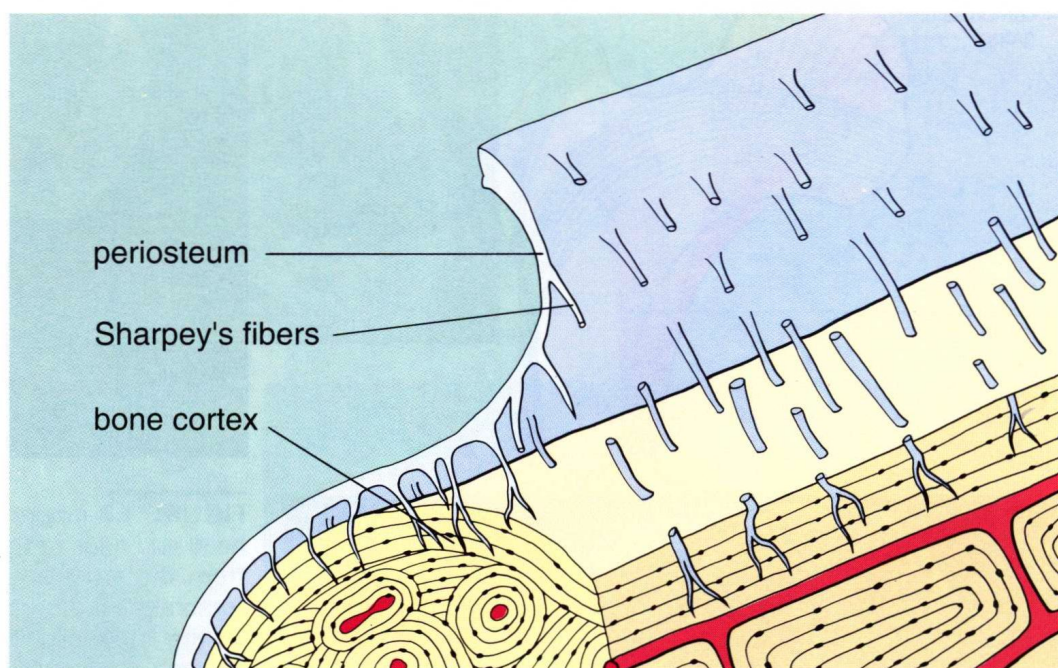


FIGURE 1.5 The fibers of Sharpey are direct continuations of periosteal fibers extending into the bone cortex.