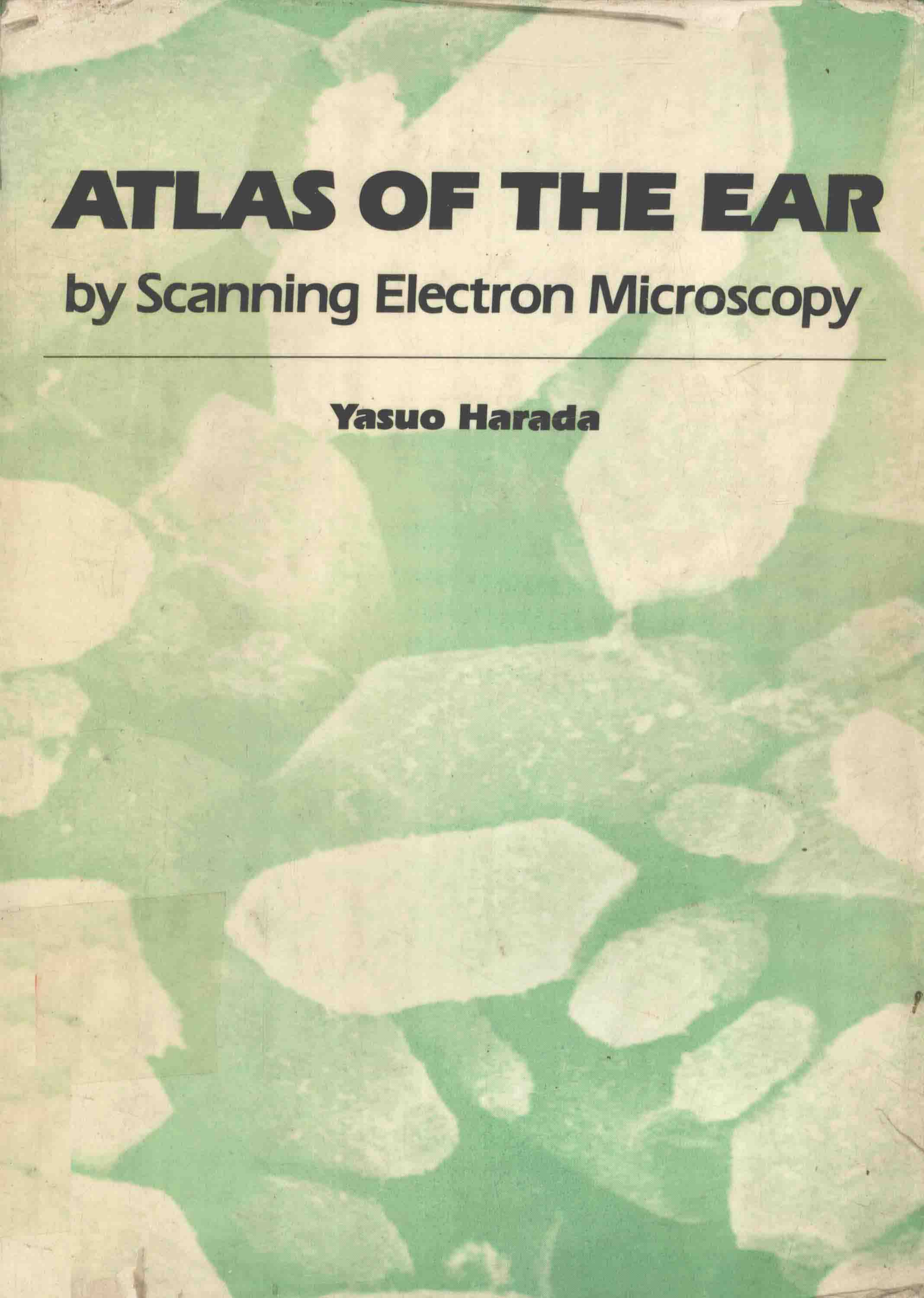

ATLAS OF THE EAR

by Scanning Electron Microscopy

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Hiroshima University Medical School
Hiroshima, Japan

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Foreword

The physiology of the semicircular canals was my main research interest before I began to study their morphology. In 1966, by utilizing the isolated semicircular canal of the frog, I was able to show that cell activity in the horizontal semicircular canal has the opposite polarity to that in the vertical canals, which was the first physiological proof of Ewald's law. Several transmitting electron microscope (TEM) studies had already reported on the morphology of the semicircular canal cristae; however, my morphological work was motivated by a strong desire to see whether the morphological polarity accorded to the physiological polarity.

In 1968 I happened to see the paper written by Dr David Lim, one of my close friends. His findings concerning the vestibular morphology, when examined by scanning electron microscopy (SEM), fascinated me a great deal because of the three-dimensional quality of the micrographs. This stimulated me to become involved in vestibular morphology. In the beginning, however, I faced many problems with specimen preparation for SEM, and the first few years were spent simply solving technical problems, especially those of artifacts.

Many of the figures in this book have been photographed with a JEOL JSM U-3 scanning electron microscope over a decade. The sharpness of these pictures still, I think, bears comparison to the definition of those taken by the more sophisticated SEM scopes currently available.

My work on the morphology and physiology of the vestibular organ led me to research into the whole inner and middle ear system. This has been intensively investigated with a JEOL JSM T200 and a JEOL JSM F15 which were recently introduced to my department. Here, these micrographs from the inner and middle ear are compiled for publication together with brief captions. What is presented in the text is generally aimed at the level of the otolaryngologist, but would also be of interest to medical students. The structure of the inner ear is complicated, as is indicated by its alternative name of 'labyrinth', and it used to be a research field not easily accessible. In this atlas emphasis is placed on the surface structure, thus enabling better understanding of the anatomy. Furthermore, this book covers almost every aspect of the inner and middle ear, such as morphology beneath the surface, the nervous system and even clinical pathology.

It is my great pleasure that this publication may contribute to the work of those concerned with the ultrastructure of the ear.

Yasuo Harada, MD

Acknowledgements

Many thanks to Prof M. Cherubino at Pavia University, Italy, who invited me to conduct research on the physiology of the inner ear. Physiological work under guidance of Prof C. Casela and Prof G. Rapuzzi at the Istituto di Fisiologia Generale dell'a Università di Pavia, was further developed in Japan and stimulated my interest in vestibular morphology.

Prof S. Kurozumi's support for this study is acknowledged.

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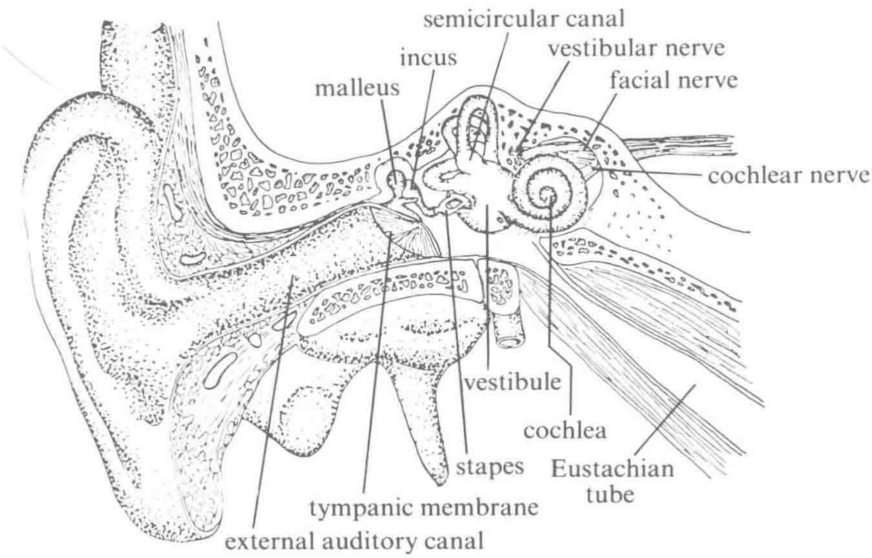
Contents

The Middle Ear



The tympanic membrane

The tympanic membrane of a human adult is oval or elliptical in shape, with its major axis 9.0–10.2 mm in length and minor axis 8.5–9.0 mm. The tympanic membrane is divided into tense and flaccid portions and histologically consists of three layers, epidermis, lamina propria and mucosa. The flaccid portion lacks the lamina propria. The annular ligament surrounds the tense portion, but it is interrupted at the flaccid portion.

(1) *Epidermis*

This is especially thick in the flaccid portion and is divided into the stratum corneum, stratum spinosum and stratum basale.

(2) *Lamina propria*

There are two layers; the radiate fibrous layer on the outside and the circular fibrous layer inside. These layers include collagen fibrils and other fine fibrils. Studies by SEM showed the radiate fibrous layer starts from the lower $\frac{4}{5}$ of the malleus manubrium (Shimada *et al.*, 1971) and ends at the annulus. The circular fibrous layer arises from the short process of the malleus, partly from the manubrium and is dense in the peripheral area of the tympanic membrane. A similar structure is seen in the guinea pig (Lim, 1970, Kawabata, 1971, Harada, 1972, Nomura, 1978).

(3) *Mucosa*

This layer consists of a single layer of squamous cells in the flaccid portion which partially includes multiple stratified cylindrical cells (Hentzer, 1969). There are microvilli in the cell surfaces and also some cells with a centriole.

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Figure 1 Epidermis (human). (**a**) There are some concave portions possibly due to the nucleus of the cell (× 400), (**b**) the surface is generally smooth, but partially desquamated (× 1300)

a

b

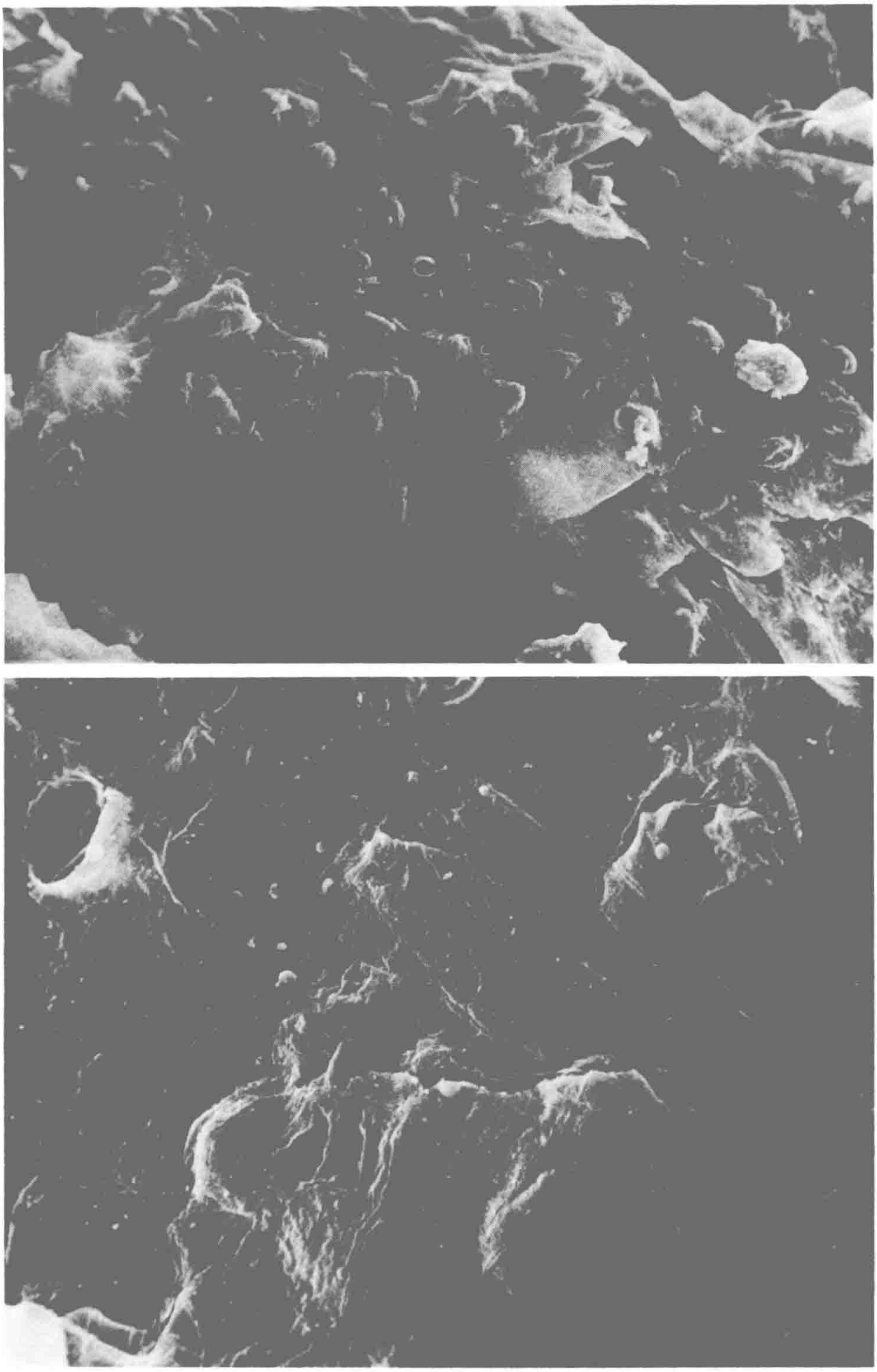

Figure 1

a

b

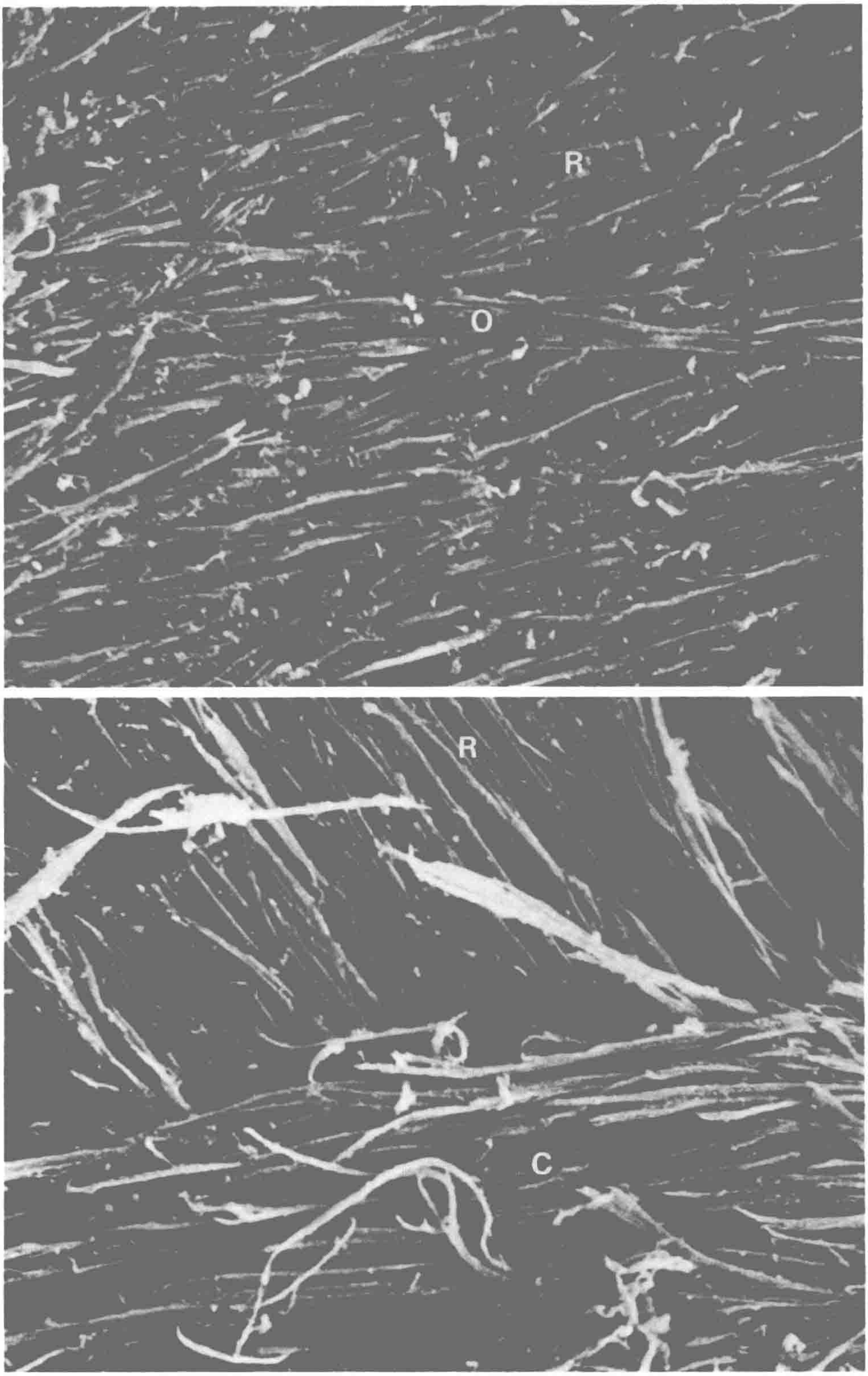

Figure 2 Lamina propria (human). C: circular fibre, R: radiate fibre, O: oblique fibre. (**a**) × 400, (**b**) × 400

a

b

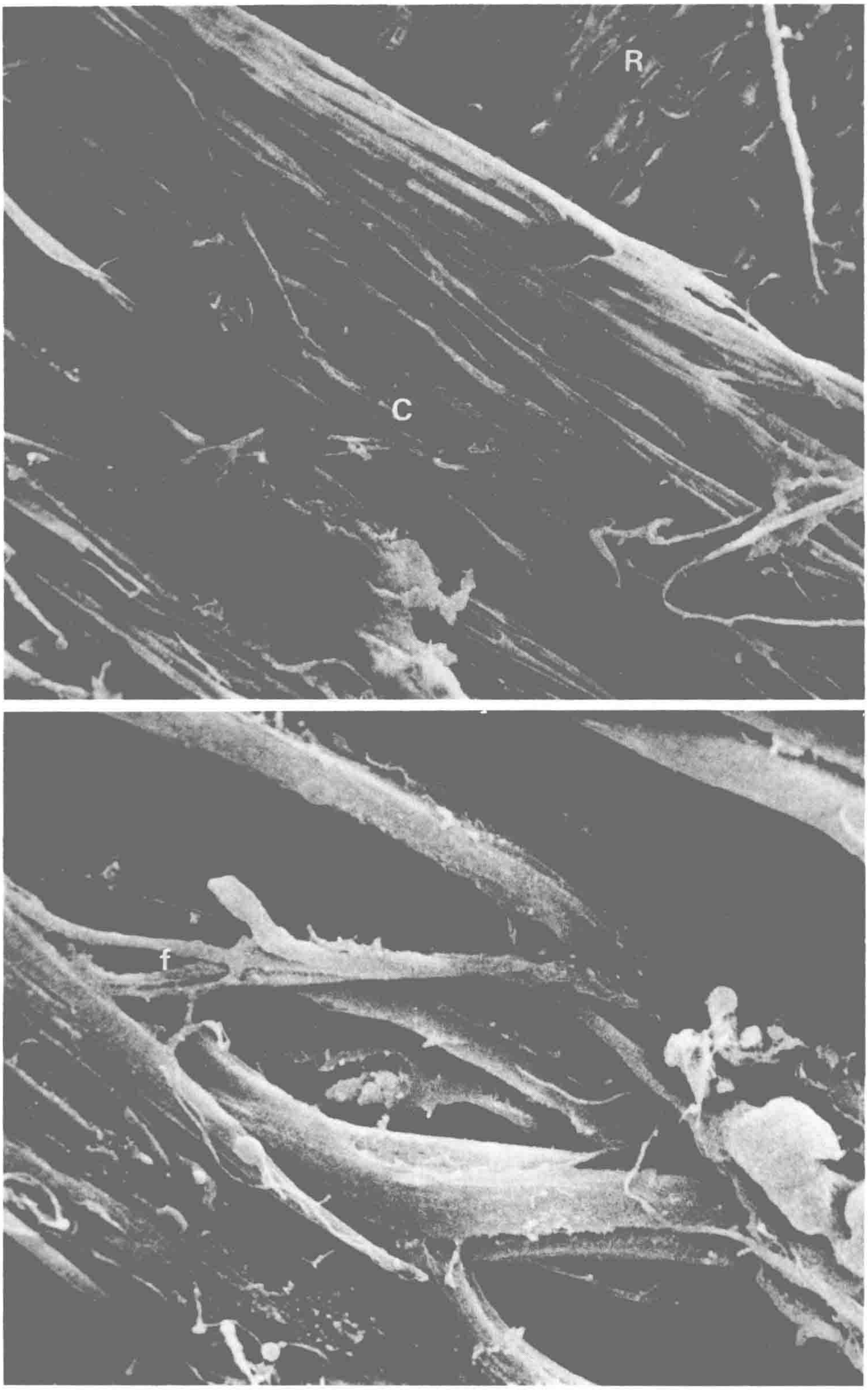

Figure 3 The circular (C) and the radiate (R) fibrous layers (human) (**a**) × 400, (**b**) × 4000

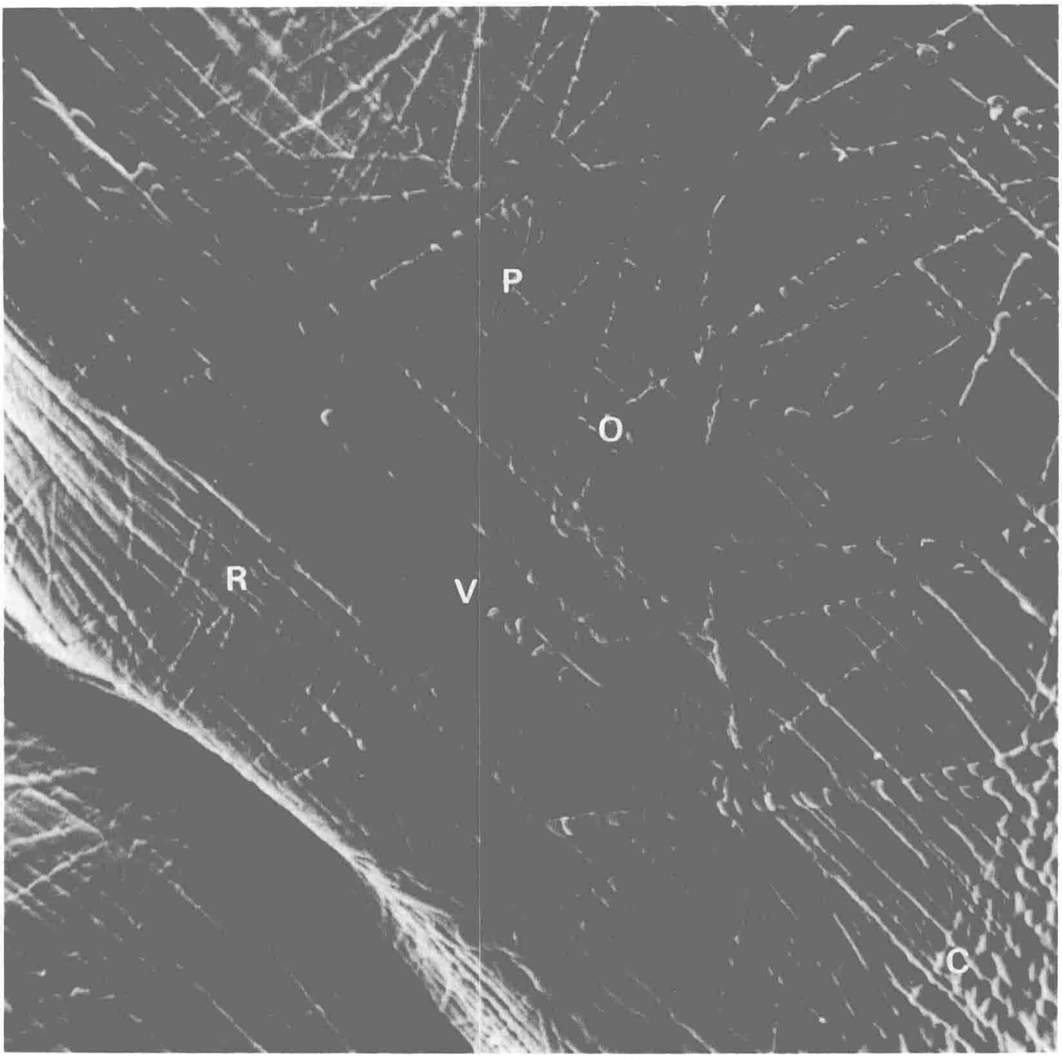

Figure 4 Lamina propria (guinea pig). The lamina propria of guinea pig is thinner than that of human. The oblique (O) and the circular fibres (C) are observed on the radiate fibres (R). Small vessels (V), which contain blood cells, are also seen (× 500)

Figure 5 Mucosa (human). The mucosa is covered by flat cells with a few microvilli. Since each cell body is relatively thin, the nucleus sometimes causes bulging on the cell surface. (**a**) Polygonal large cells are seen together with smaller cells (× 1400), (**b**) a cell with a centriole (× 4200)

a

b

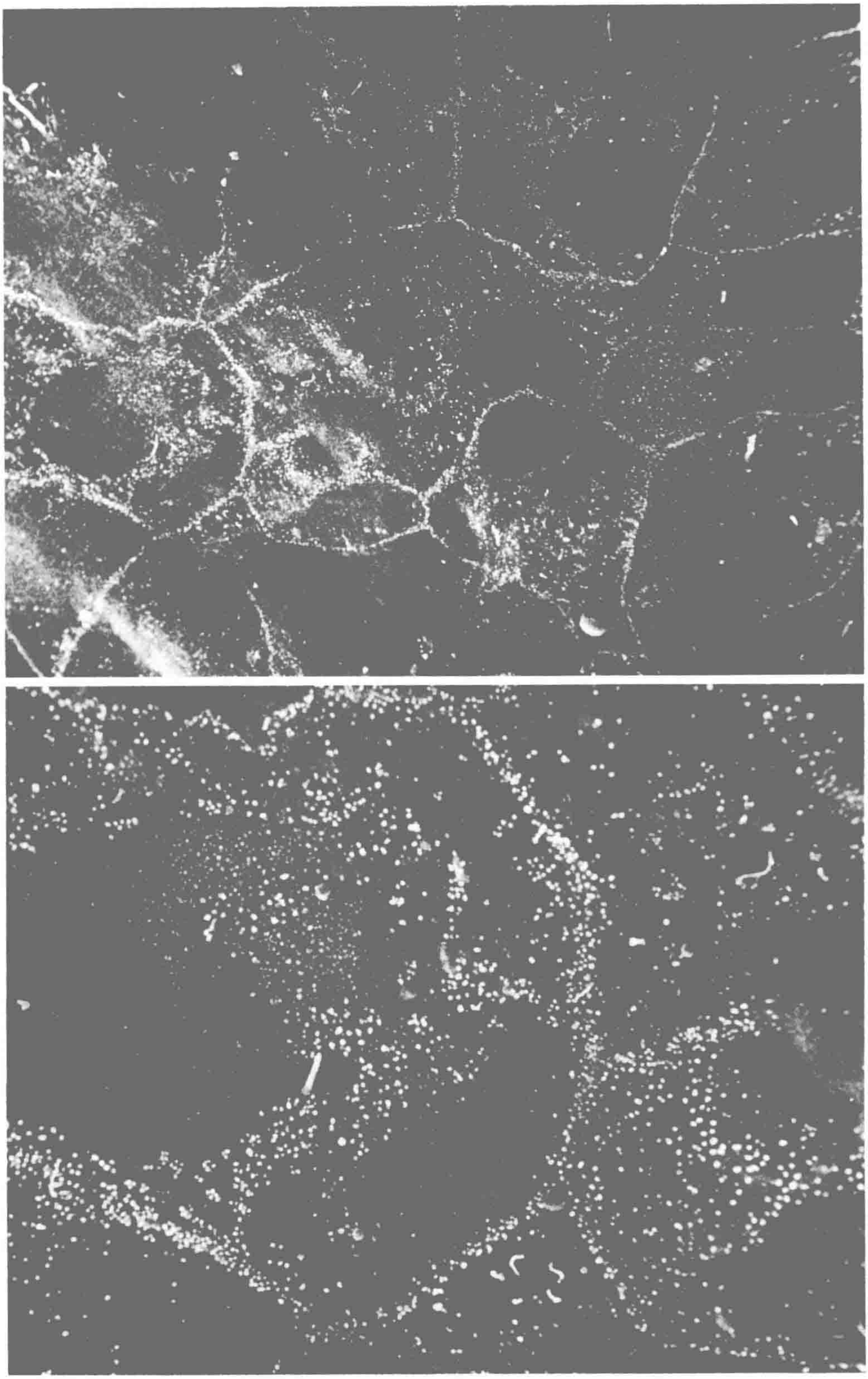

Figure 5