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The Distribution of the Exfoliation Material in the Iris from Eyes with Exfoliation Syndrome (Pseudoexfoliation of the Lens Capsule)

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Summary. 1. The internal limiting membrane on the posterior surface of the iris appeared crumpled, interrupted, and mixed with exfoliation material.

2. No exfoliation material was found between the basal pigment cells or between the basal and the apical pigment cells.

3. The apical pigment cells showed numerous cytoplasmic processes towards the posterior chamber.

4. The exfoliation material was especially abundant in the anterior 20–30 μ of the stroma.

5. Exfoliation material was also found deep in the stroma adjacent to fibroblast-like cells, and in the intercellular space of the sphincter and dilatator muscles.

Zusammenfassung. 1. Die Membrana limitans interna auf der hinteren Irisfläche war runzlig, durchbrochen und mit Exfoliationsmaterial durchsetzt.

2. Zwischen den basalen Pigmentzellen sowie zwischen den basalen und apicalen Pigmentzellen wurde hingegen kein Exfoliationsmaterial beobachtet.

3. Die apicalen Pigmentzellen zeigten zahlreiche cytoplasmatische Fortsätze in Richtung auf die hintere Augenkammer.

4. Das Exfoliationsmaterial war in den vorderen 20—30 μ des Stroma besonders reichlich vorhanden.

5. Das Exfoliationsmaterial wurde auch tief im Stroma in der Nähe von fibroblastenähnlichen Zellen und im Intercellulärraum der Sphincter- und Dilatatormuskeln gefunden.

Introduction

In a light microscopic study on the exfoliation syndrome Busacca (1928) described a "Glashaut" covering the anterior and the posterior iris surfaces. He further maintained that hyaline changes could be observed between the sphincter and the dilatator muscles in such eyes. Most later investigators have concentrated on the occurence of exfoliation material on the surfaces against the aqueous humour, i.e. on and within the lens capsule, on the posterior and the anterior iris surfaces, on the zonular fibres, on the ciliary body, and between the inner trabeculae of the chamber angle (Dvorak-Theobald, 1954; Sunde, 1956; Gifford, 1957; Bertelsen *et al.*, 1964; Ashton *et al.*, 1965; Hörven, 1966; Dark *et al.*, 1969). Recently, however, it has been shown that such material is also present within the iris tissue (Shakib *et al.*, 1965; Ringvold, 1969).

In a previous paper (Ringvold, 1970b) it has been shown that there is some evidence for believing the exfoliation material to be of a collagenous nature.

In order to elucidate the process of synthesis of exfoliation material, it was considered necessary to describe its exact distribution within the iris.

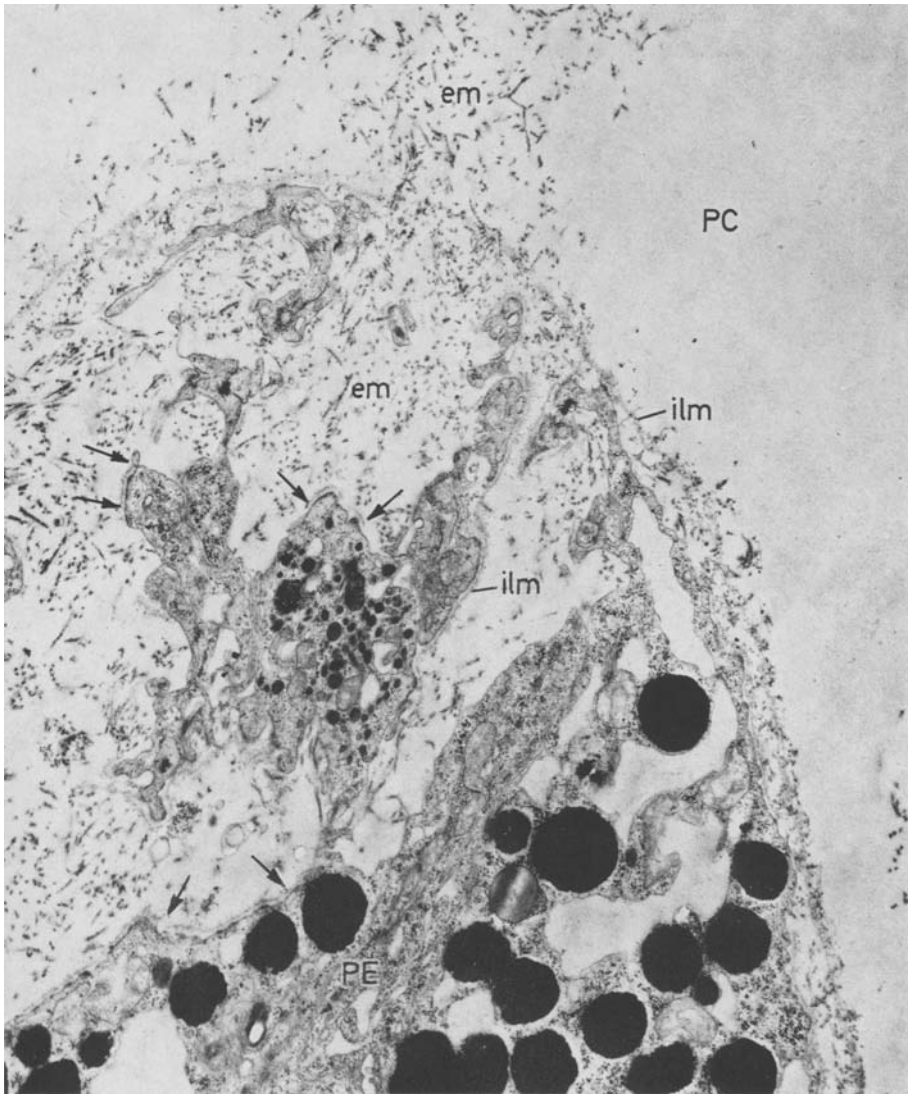

Fig. 1. The internal limiting membrane (*ilm*) covering the apical pigment epithelial cells (*PE*) towards the posterior chamber (*PC*) shows numerous discontinuities at arrows. Exfoliation material (*em*) is seen on and within the internal limiting membrane. ×12,000

Material and Methods

Iris tissue from eight cataractous eyes with exfoliation syndrome were studied. The patients were from 54 to 83 years old at the time of operation. The tissue was fixed in 1% OsO_4, embedded in Araldite, and sections were stained with uranyl acetate and lead citrate. Further details on preparation procedures are described in a previous paper (Ringvold, 1969), where tissue from the same irides was used.

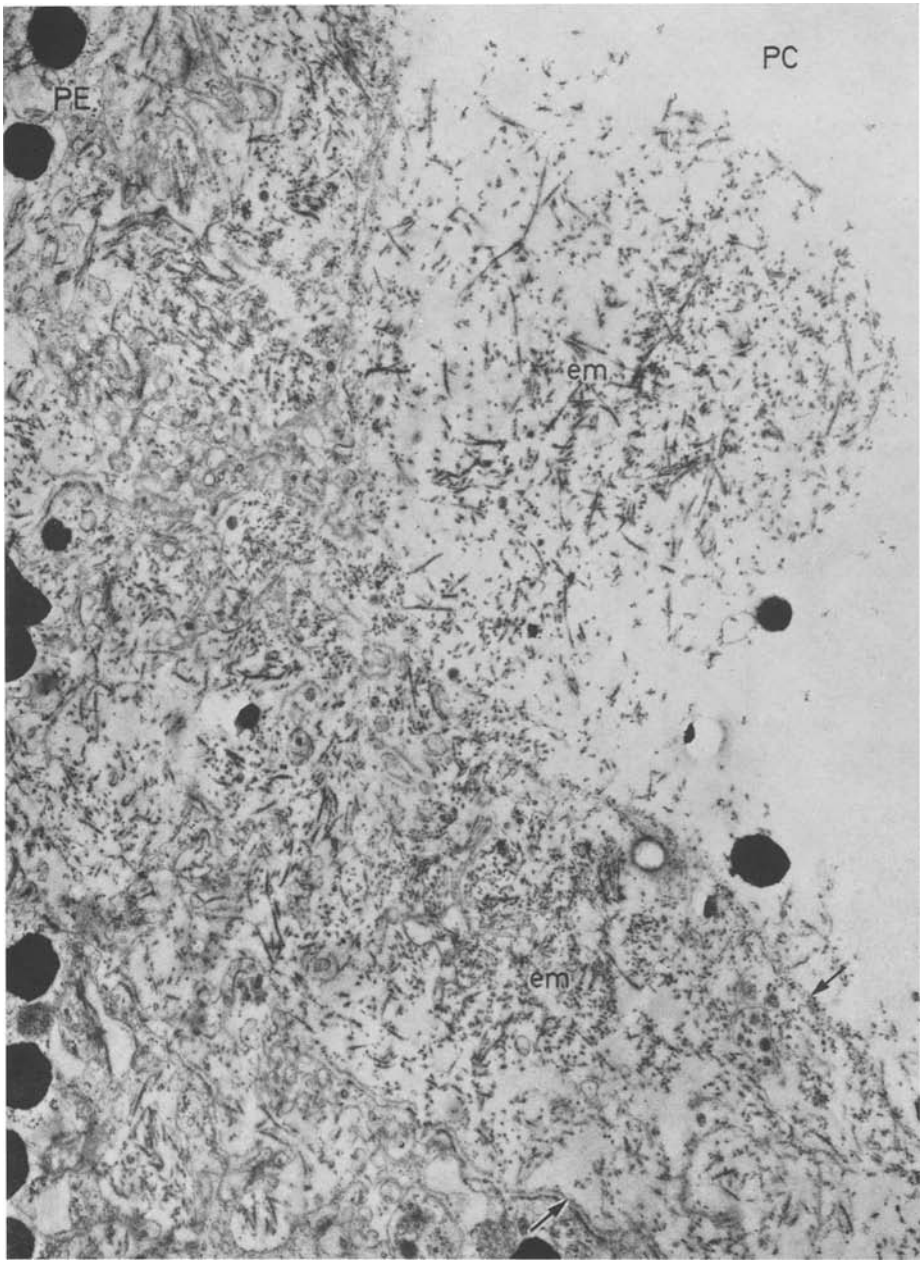

Fig. 2. The pigment epithelium (*PE*) is covered by a multilayered internal limiting membrane (*ilm*) the thickness of which is marked with arrows. Exfoliation material (*em*) forming the characteristic bush-like aggregate of Busacca protrudes into the posterior chamber (*PC*). ×12,000

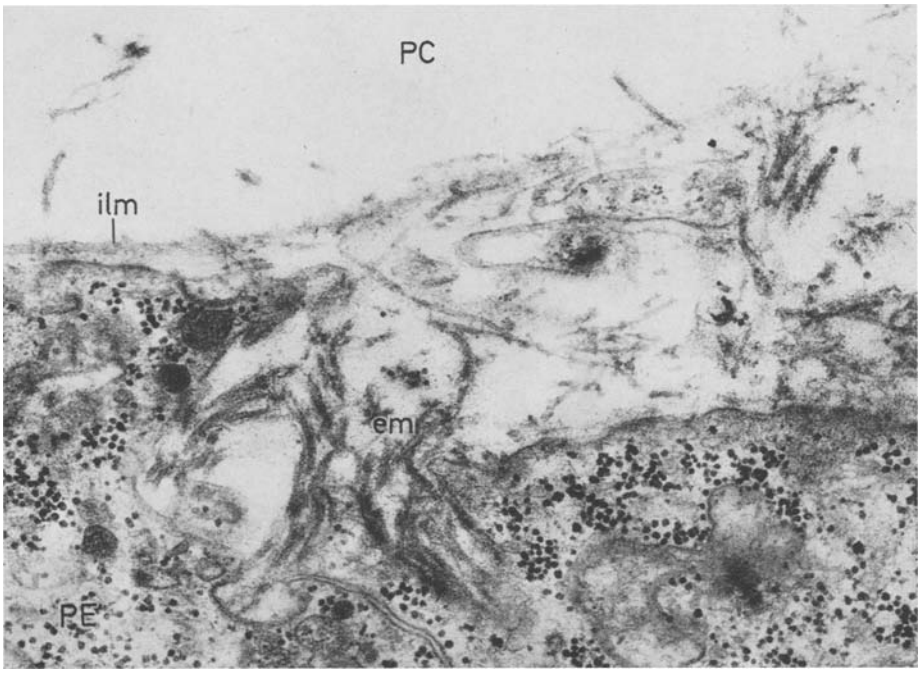

Fig. 3. Exfoliation material (*em*) is seen between the pigment epithelium (*PE*) and the internal limiting membrane (*ilm*). ×30,000

Results

Where nothing else is said, the following description is valid for all preparations.

The internal limiting membrane on the posterior surface of the pigment epithelium appeared as crumpled, interrupted bands (Fig. 1), often showing overlapping, or appearing as a bi- or multilayered structure (Fig. 2). Within this membrane exfoliation material was found, forming together with the basement membrane a broad zone (measuring up to 4 μ in thickness) of loosely packed material on the epithelial surface (Figs. 1 and 2). Anchored in this zone numerous bush-like aggregates of exfoliation material protruded some distance into the posterior chamber (Fig. 2). Exfoliation material was also observed adjacent to the cell membrane beneath the basement membrane (Fig. 3), and in clefts between pigment cells of the apical layer (Fig. 4). However, it was never found between pigment cells of the basal layer or between the basal and the apical pigment cells.

The apical pigment cells showed numerous cytoplasmic processes towards the posterior chamber giving the cell surface an extremely wavy appearance (Fig. 1). The indentations between these processes were filled with exfoliation material (Fig. 5). Apparent vacuoles containing exfoliation material also occured in the apical part of these cells probably representing obliquely sectioned indentations (Fig. 5).

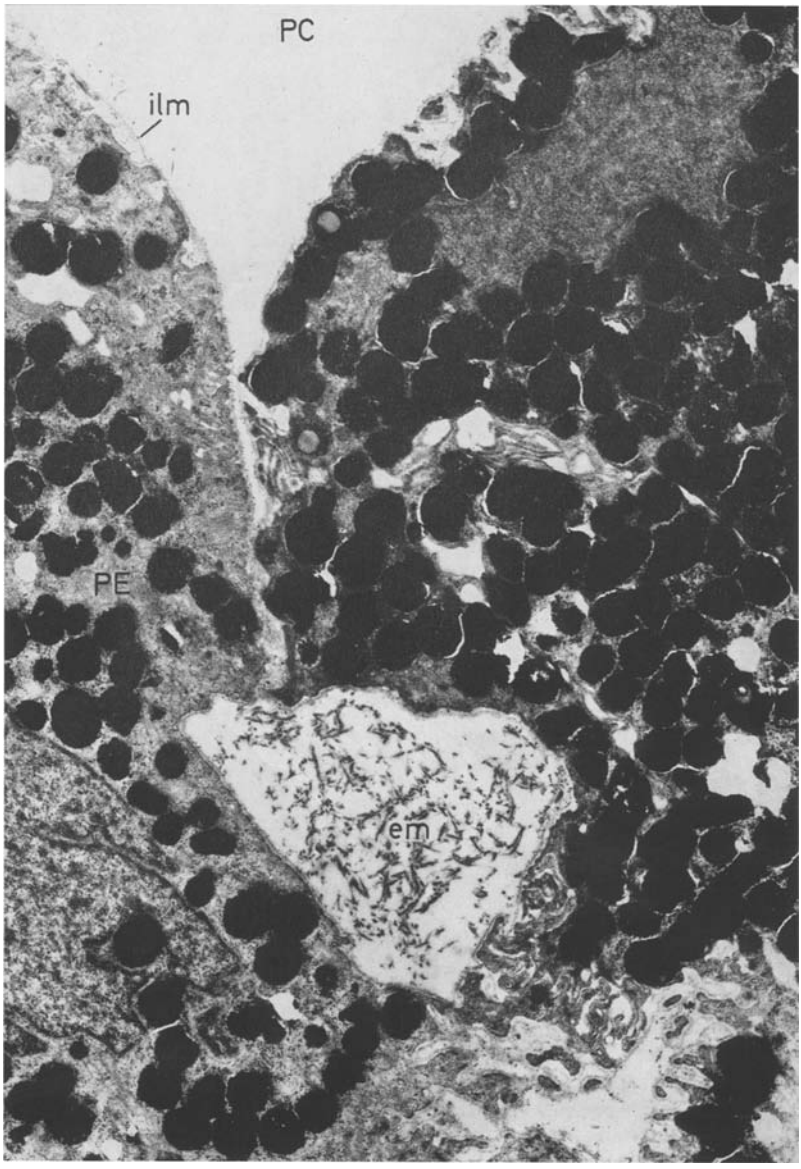

Fig. 4. A cleft containing exfoliation material (*em*) is present between pigment epithelial cells of the apical layer. ×6,900

In addition to considerable amounts of exfoliation material around iris vessels as earlier described (Shakib *et al.*, 1965; Ringvold, 1969), it occured especially abundant in the anterior layer of the stroma; i.e. 20–30 μ measured from the iris surface. In this zone exfoliation material appeared as aggregates, seemingly dislocating the anterior border cells (Fig. 6), or scattered in the intercellular

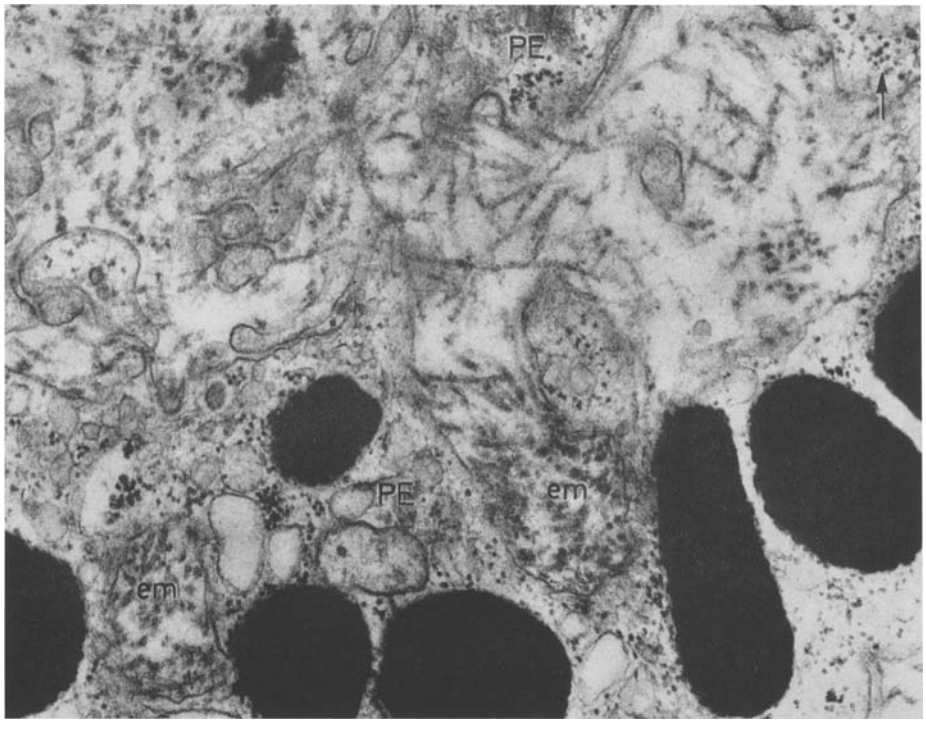

Fig. 5. Pigment epithelial cells (*PE*) of the apical layer is shown, and the arrow indicates the direction towards the posterior chamber. Marked indentations of the cellular wall contain exfoliation material. ×30,000

space. Otherwise exfoliation material was seldom found in the stroma, and when it appeared it mostly was close by cellular elements. These cells were supposed to be fibroblasts. Similar to the apical pigment epithelial cells indentations and apparent vacuoles containing exfoliation material were found in anterior border cells and stromal cells (Fig. 7). It is noteworthy that some of these cells had extremely irregular outlines.

Furthermore, aggregates of exfoliation material were found between the dilatator muscle cells (Fig. 8), between the sphincter muscle cells (Fig. 9), and in the stromal part adjacent to these muscles. Exfoliation material occured between the sphincter muscle cells in 7 of the 8 investigated eyes.

The normally occuring extracellular components (Ringvold, 1970c) were also present in eyes with exfoliation syndrome. These components showed no irregularities apart from the earlier described changes in the basement membrane of iris vessels (Ringvold, 1969), and the alteration of the internal limiting membrane of the iris reported in this study.

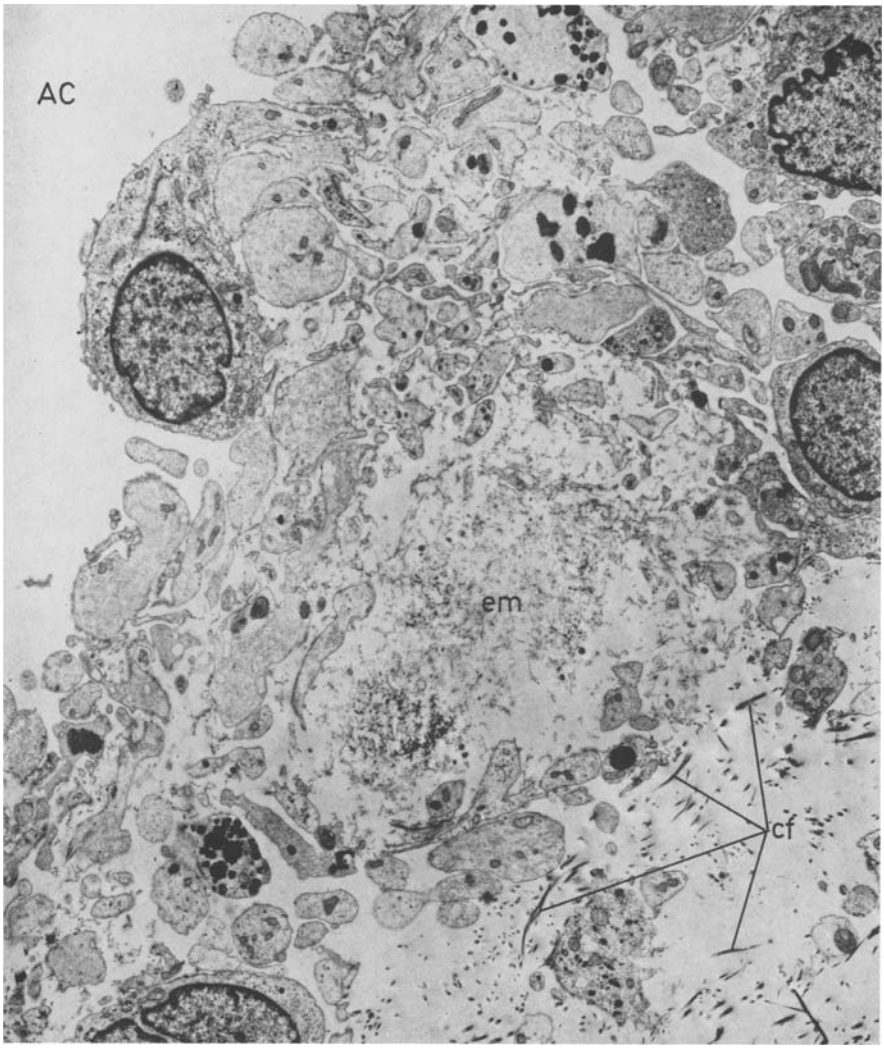

Fig. 6. Great amounts of exfoliation material (*em*) is present between the anterior border cells. *cf* collagen fibrils, *AC* anterior chamber. ×4,600

Discussion

This study confirms earlier reports (Bertelsen *et al.*, 1964; Ashton *et al.*, 1965) showing exfoliation material in the internal limiting membrane on the posterior iris surface. Exfoliation material has previously been found in other intraocular basement membranes; i.e. in the lens capsule (Bertelsen *et al.*, 1964; Ashton *et al.*, 1965; Dark *et al.*, 1969), in the internal limiting membrane of the ciliary body (Shakib *et al.*, 1965), and in the basement membrane of the iris vessels (Ringvold, 1969). In addition, as shown in this work, it also appears mixed with

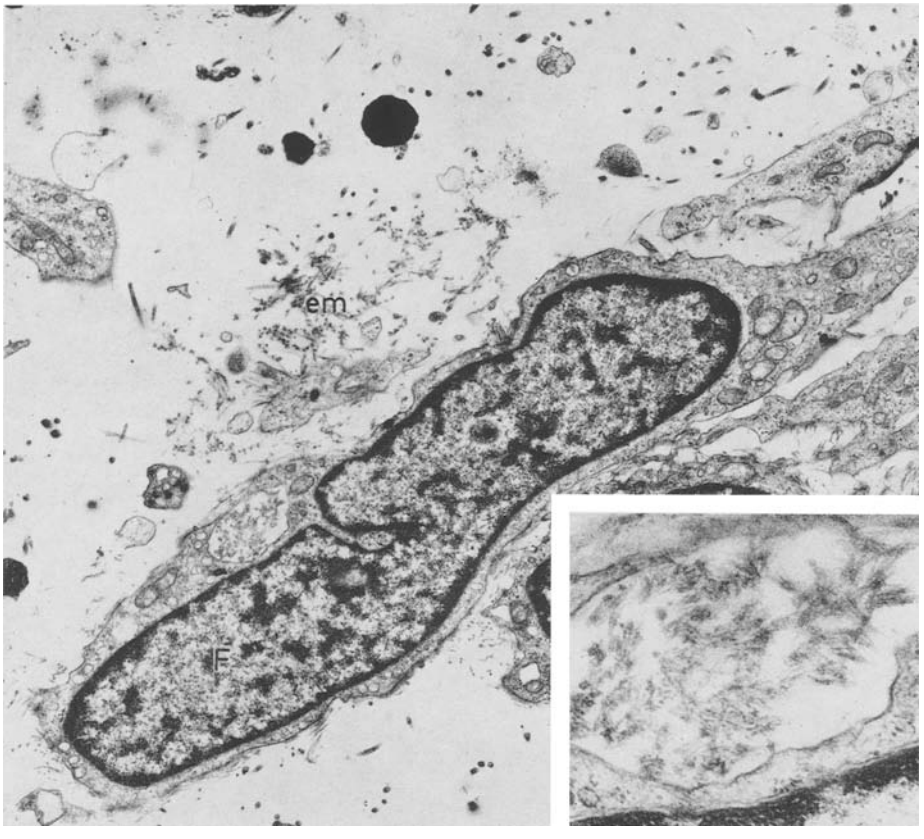

Fig. 7. Fibroblast-like cell (*F*) surrounded by exfoliation material (*em*) lying deep in the iris stroma. ×6,900. The insert shows details from this cell. ×30,000

the basement membrane-like substance in the intercellular space of the sphincter and the dilatator muscles.

These observations indicate an intimate relationship between exfoliation material and intraocular basement membranes. On account of this relationship and the finding of thin, interrupted basement membranes in iris vessels from eyes with exfoliation syndrome, it has been assumed that some biochemical disturbance might be responsible both for the occurence of exfoliation material and the basement membrane changes (Ringvold, 1969). The finding of discontinuities in the internal limiting membrane of the iris described in this study supports this assumption.

In a previous paper (Ringvold, 1970b) some evidence is given that exfoliation material consists of collagen. This could indicate that the exfoliation material derives from the basement membrane collagen. Consequently, the presence of exfoliation material may be due to changes in the collagen synthesis or to an altered mode of aggregation of the collagen component in the basement membrane.

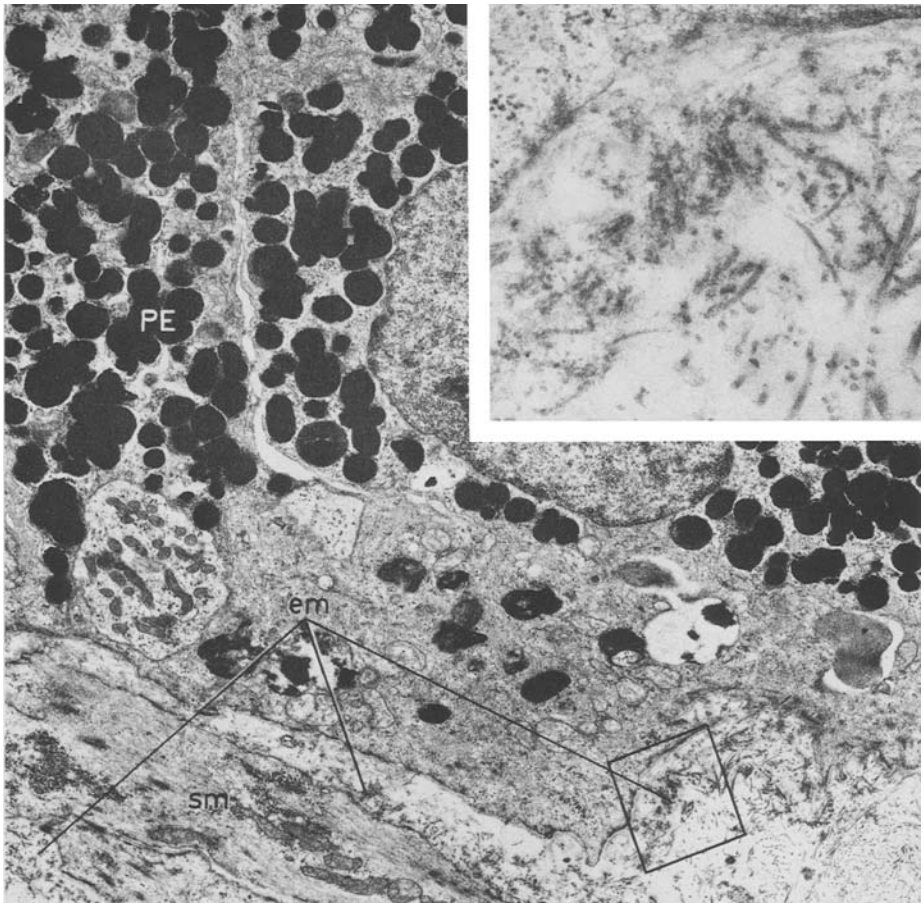

Fig. 8. Exfoliation material (*em*) is seen between the dilatator muscle cells. *sm* smooth muscle cell. ×6,900. The insert shows details from the square on the micrograph. ×30,000

However, the present investigation definitely shows exfoliation material also in stroma regions where no basement membrane substance is present. It seems improbable that aggregates of this material lying deep in the stroma, closely related to fibroblast-like cells or muscle cells is transported into the iris from outside. Rather, it indicates that exfoliation material is synthesized within the stroma itself.

It is well-known that collagen is synthesized by the fibroblasts. Furthermore, earlier reports have shown that the basement membrane contains collagen (Pirie, 1951; Kefalides, 1967). If an altered collagen synthesis leads to morphological manifestations, they are expected to occur in those regions where collagen is synthesized; i.e. adjacent to fibroblasts and adjacent to cells covered by a basement membrane.

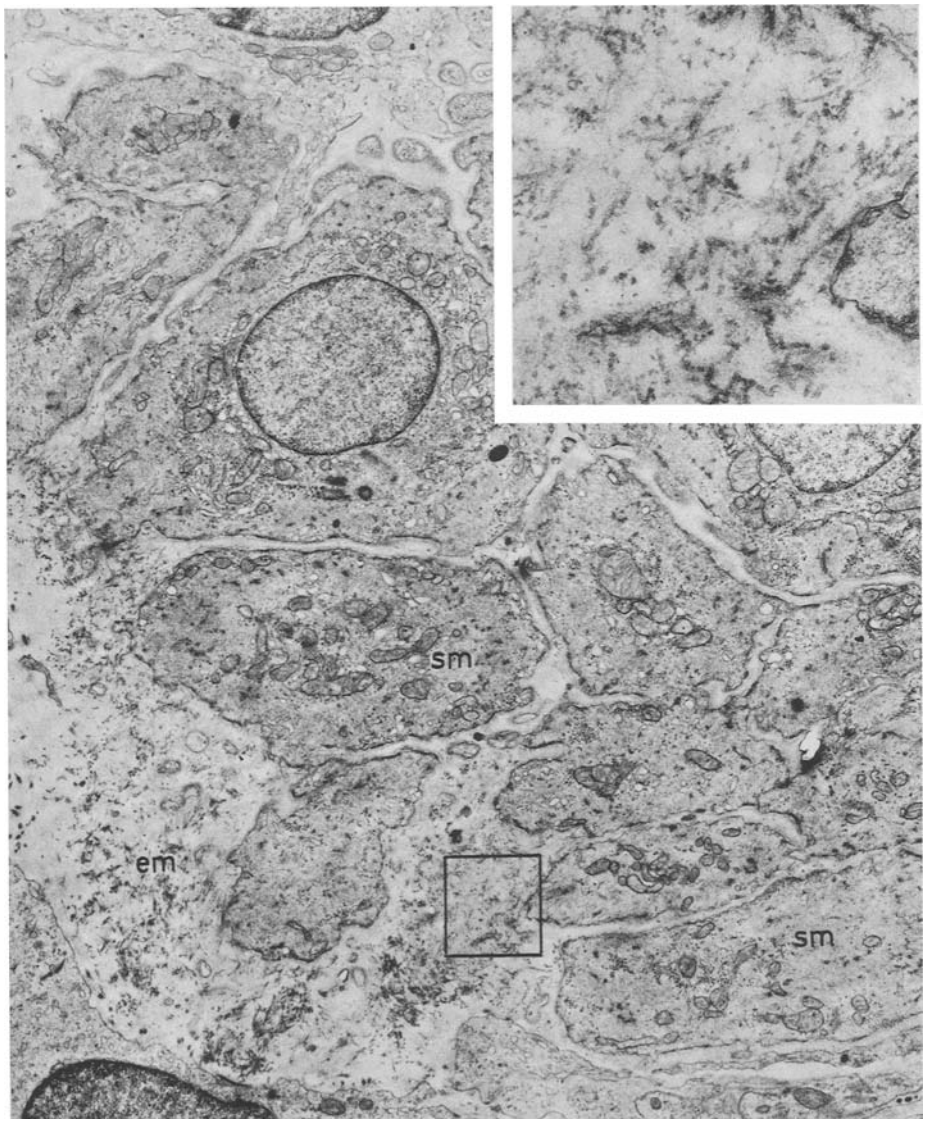

Fig. 9. Exfoliation material (*em*) is present between the sphincter muscle cells. ×6,900. The insert shows details from the square on the micrograph. ×30,000

As shown in this study exfoliation material is found around fibroblast-like cells in the stroma, and in some basement membranes, that appeared altered in certain regions. In conclusion, therefore, these observations are all compatible with the interpretation that the appearance of exfoliation material reflects changes in the synthesis of the collagen molecule or in the formation of fibrillar aggregates.

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