ULTRASTRUCTURAL CHANGES OF THE BASAL LAMINA DURING THE HAIR GROWTH CYCLE

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INTRODUCTION

The "hyaline membrane" (glassy or vitreous membrane), the noncellular layer that invests the entire hair follicle, is visible with the light microscope. During hair growth cycles (5), this membrane undergoes characteristic morphological modifications. Under the light microscope, the hyaline membrane appears thin and inconspicuous around the follicle during anagen and telogen (growing and resting phases of the hair follicle). At the onset of catagen (the transitional phase between anagen and telogen), the PAS-positive membrane around the lower part of the follicle becomes hypertrophied. In the later stages of catagen, this lower section of the follicle atrophies and the surrounding hyaline membrane appears like a thick wrinkled sac (2, 5, 13).

Under the electron microscope, the hyaline membrane of anagen follicles consists of an inner basal lamina and two outer layers of orthogonally arranged collagen fibers (7, 9). The ultrastructure of the thickened hyaline membrane of the catagen follicle, however, has not been described. In this study, I have observed that during catagen the basal lamina undergoes an extensive pleating process that causes the hyaline membrane to resemble the thick wrinkled sac seen under the light microscope. The details of these ultrastructural changes are reported below.

MATERIALS AND METHODS

Small pieces of back skin from 19- to 22-day-old albino mice were excised and immersed in ice-cold 1% osmium tetroxide buffered to pH 7.4–7.6 with either veronal acetate or phosphate (4, 6). The tissues were fixed for 2 hr and then dehydrated in an ascending series of ethanol and embedded in Araldite (3). 1-μ sections were stained in azure blue B for orientation purposes. Thin sections were successively stained in aqueous uranyl acetate and lead citrate (8) and then examined in an RCA EMU 3 F or Phillips EM 200 electron microscope.

RESULTS

In anagen hair follicles, the three components of the hyaline membrane are interposed between the cells of the outer root sheath and the connective tissue sheath (Fig. 1). The amorphous, or occasionally finely fibrillar, basal lamina is about 800 A thick and conforms to the smooth contours of the plasma membrane of the outer root sheath at a distance of about 1000 A. The inner layer of collagen fibers lies parallel to the long axis of the hair, whereas the outer layer is at right angles to the inner one (Fig. 1). This orthogonal arrangement

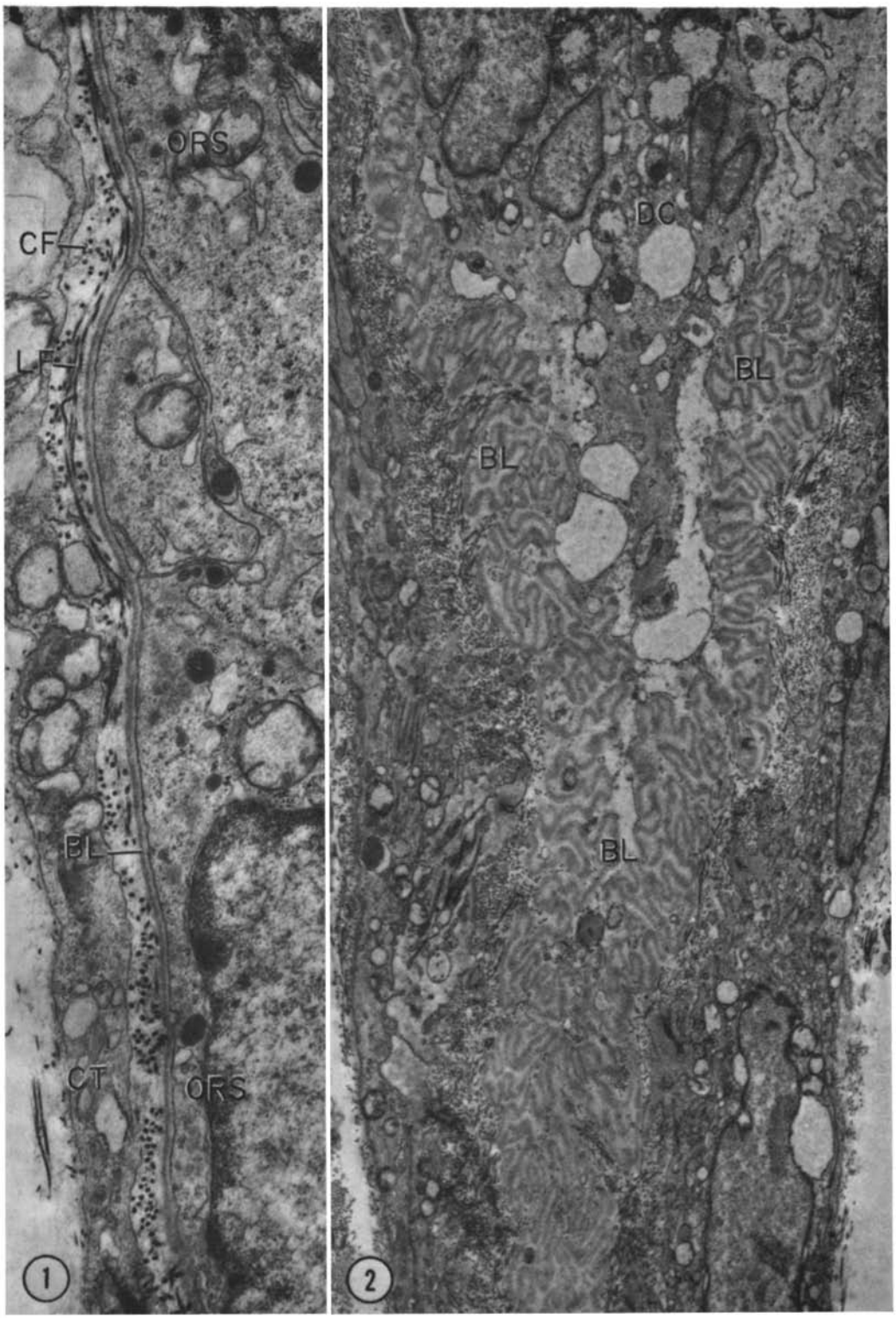

FIGURE 1 Electron micrograph showing the hyaline membrane in the anagen follicle. The basal lamina (*BL*) and the two layers of collagen fibers (*LF*) and (*CF*) are interposed between the outer root sheath (*ORS*) and the connective tissue sheath (*CT*). Note that the basal lamina follows the smooth contours of the outer root sheath cells. × 24,000.

FIGURE 2 Electron micrograph of the highly pleated basal lamina (*BL*) of the catagen follicle. Note the disintegrating cells (*DC*) enclosed by the folded basal lamina. × 10,000.

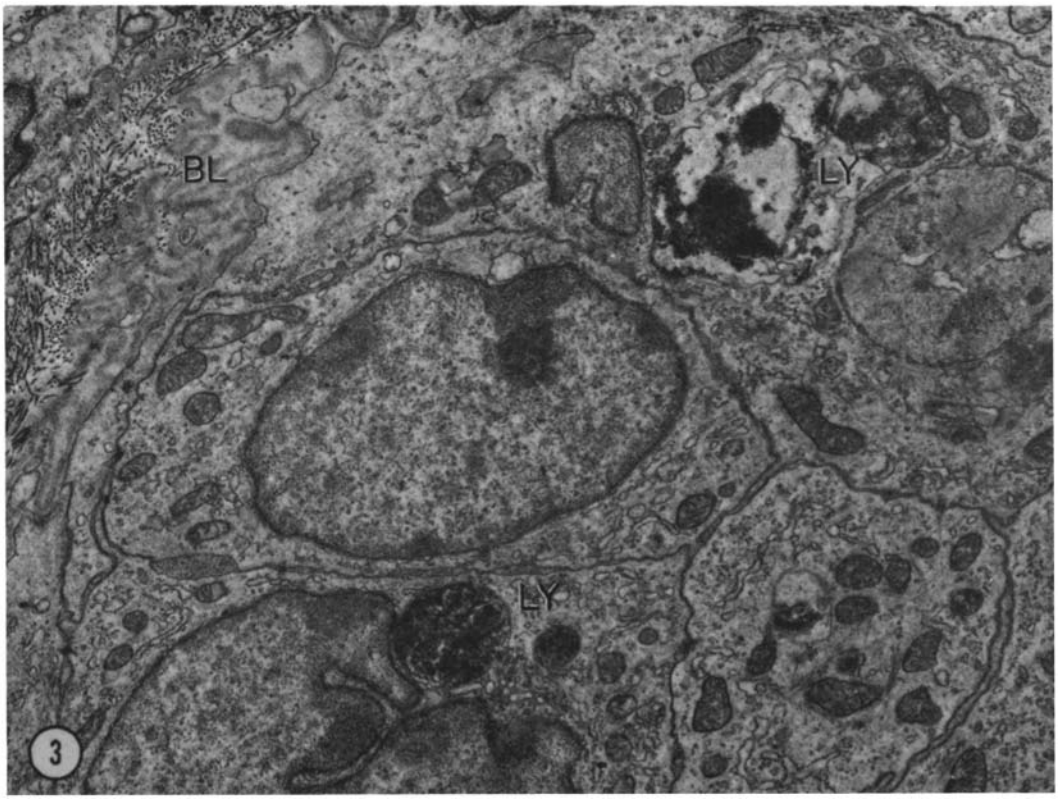

FIGURE 3 Portions of the outer root sheath cells from an early catagen follicle showing the large number of lysosomes (*LY*). The plasma membrane and the basal lamina (*BL*) have undergone some infoldings. × 11,000.

of collagen fibers resembles somewhat that of the basement lamella of amphibian tadpole skin (12).

At the onset of catagen, the cells in the lower part of the hair follicle begin to form large numbers of membrane-bounded dense bodies, presumably lysosomes (Fig. 3). Simultaneously with the appearance of dense bodies, the plasma membranes of these cells undergo invagination and the basal lamina follows most of these infoldings (Fig. 3). At a later stage, when some of cells have undergone resorption, the basal lamina appears highly pleated (Fig. 2), with remnants of degenerating cells often trapped in the infoldings (Fig. 2). During the last stages of catagen, the now highly pleated basal lamina encloses the atrophic cells of the lower portion of the follicle as the latter undergoes complete dissolution. Even though the basal lamina has undergone extensive folding, there is no appreciable change in its thickness. Finally, at the end of catagen, the highly plicated basal lamina is completely resorbed, and simultaneously the two layers of collagen fibers lose their orthogonal arrangement and seem to blend into the surrounding connective tissue.

DISCUSSION

The present study has demonstrated an extensively pleated basal lamina around the entire lower part of the catagen follicle. Since there are no appreciable changes in the two layers of collagen fibers, the unusual thickening of the hyaline membrane reported in previous studies (2, 9, 13) must be due to the pleatings of the basal lamina.

It is pertinent here to speculate on the origin of the pleated basal lamina. Light microscopic studies have demonstrated that during catagen the whole lower part of the hair follicle undergoes degeneration. The large numbers of lysosome-like dense bodies in these cells shown by this study might be responsible for the dissolution of the cells. Once the

cells are completely resorbed, it appears that the basal lamina remains and folds because of lack of association with cells. This conclusion is supported by the fact that the pleated basal lamina is found only around the lower part of the hair follicle where considerable cell death occurs. Around the upper part of the hair follicle, which does not undergo any degenerative changes, the basal lamina remains unchanged.

A layered or folded basal lamina has been found in certain experimental and pathological conditions (1, 10, 11, 14). In diabetes mellitus, for example, the blood vessels are known to be sites of both endothelial destruction and proliferation. The multilayered basal lamina seen around such capillaries may be regarded as left over by the successive generations of resorbed cells.

SUMMARY

Under the electron microscope, the hyaline membrane consists of three components: a basal lamina and two layers of orthogonally arranged collagen fibers. During catagen, as the cells in the lower part of the hair follicle are resorbed, the basal lamina undergoes an extensive pleating process that results in the thickened hyaline membrane seen under light microscopy.

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