An Electron Microscopic Study of the Human Epidermal Keratinocyte

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Summary. 1. The epidermis of the flexor surface of the upper arm of human subjects was studied with the electron microscope. 2. The cytoplasm of the keratinocytes in the basal layer contained many tonofilaments, ribosomes and other cell organelles. The tonofilaments were arranged singly or in loose bundles and many were attached to the inner membrane of the desmosomes. Along the basal border of the cells pinocytotic vesicles could be seen at different stages of development. 3. The keratinocytes in the stratum spinosum differed from those in the basal layer in two main ways: (a) The tonofilaments were grouped together into large compact bundles known as tonofibrils and it was possible to determine a definite beading or cross banding along the length of some of the filaments. (b) The cells were assuming a flattened shape. 4. The keratinocytes in the stratum granulosum possessed large numbers of irregularly shaped keratohyaline granules. The granules were strongly osmiophilic and were always situated on a meshwork of tonofibrils. The keratohyaline granules had no internal structure. The nuclei and mitochondria showed evidence of degeneration. 5. The keratinocytes in the stratum corneum were long and flattened. The cell walls showed increased electron density and were considerably thickened. The cytoplasm was filled with closely packed fibres separated by a small amount of lucent matrix. The fibres were grouped together in bundles running in different directions within the flattened squames. The fibres had along their entire length alternating areas of high and low electron density. The keratohyalin granules had disappeared and nothing remained of the nuclei or the organelles. In the deepest cells of this region the fibres were sometimes loosely packed leaving large irregular open spaces. This area corresponded to the stratum lucidum. In the most superficial layers of the stratum corneum the fibres appeared to be breaking down so that little remained within the keratinocyte except large lucent spaces. The desmosomes showed distinct structural changes. 6. An attempt was made to correlate the structural changes in the different epidermal layers with the process of keratinization. The possible part that keratohyalin may play in the process of thickening of the cell walls was discussed. The relationship between the desmosome and its dynamic environment was considered.

Introduction

The present work on the human epidermis is a continuation of similar studies on guinea pig skin (SNELL, 1965, a, b, c). An attempt has been made to determine the fine structure of keratohyalin and tonofibrils in view of the continuing uncertainty of the role played by these structures in the formation of keratin. Particular attention has also been paid to the plasma membrane of the keratinocyte and its relationship with the plasma membranes of other cell types found in the epidermis.

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Materials and Methods

Skin biopsies were taken from the flexor surface of the upper arm. The specimens were placed immediately in cold 6.25 % glutaraldehyde in 0.1 M cacodylate buffer and the greater part of the dermis was removed under a dissecting microscope. The specimens were then placed in fresh cold glutaraldehyde and sliced up into small fragments measuring no more than 0.5 mm² with a razor blade. After fixation for two hours the fragments were transferred to ice cold 1 % osmium tetroxide buffered to pH 7.4 with veronal acetate buffer and further fixed for one hour. The tissues were dehydrated in ethanol and embedded in epoxy resins according to the method of Luft (1961). Sections were cut with an L.K.B. Ultratome, using a glass knife and “stained” with an ice cold saturated solution of uranyl acetate in ethanol. In this study an R.C.A. E.M.U. 3 G electron microscope was used.

Results

The fine structure of the human keratinocyte will be described under the following headings: 1. the dermo-epidermal junction; 2. the basal layer; 3. the stratum spinosum; 4. the stratum granulosum; 5. the stratum lucidum and stratum corneum.

Dermo-Epidermal Junction

The basement membrane was seen as a dense homogeneous band of variable width (300—750 Å) which closely followed the contours of the basal cell and its projections (Fig. 1). A narrow zone of low electron density approximately 300 Å in width separated the membrane from the walls of the cells in the basal layer. At intervals along the course of the membrane thickenings occurred and these coincided with adjacent thickenings of the plasma membrane of the basal keratinocytes. No thickenings were seen where the basement membrane came close to a melanocyte (Fig. 2). At the sites of the thickenings the osmiophilic granules of the basement membrane showed increased electron density. Between the basement membrane thickening and the adjacent thickening of the plasma membrane of the keratinocyte a single dense lamina measuring 50 Å could be seen. The whole complex is referred to as a hemi-desmosome.

Beneath the basement membrane many collagen fibres were seen. The majority of the fibres lying close to the membrane appeared to be running in one direction and parallel with the basement membrane; the deeper collagen fibres had no definite organization.

The Keratinocyte in the Basal Layer

The nucleus was round or oval in shape and often slightly indented. The cytoplasm contained many filaments and ribosomes (Fig. 1). The tonofilaments were arranged singly or in loose bundles throughout the cytoplasm; many converged to be attached to the inner membrane of the desmosomes. Vesicles that differed in shape and size were also present. Some of the vesicles formed part of the endoplasmic reticulum. Along the basal border of the cells pinocytotic vesicles were seen at different stages of development; they formed only along the cell membranes between the desmosomal plaques. Numerous ribosomes were scattered throughout the cytoplasm or were adherent to the endoplasmic reticulum. Large electron dense melanin granules or melanosomes were seen in different parts of the cytoplasm.