Keratin expression in the human hair follicle

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ABSTRACT

During the past 20 years there has been an impressive accumulation of scientific literature on the proteins which are involved in the formation and differentiation of the hair. It is clear that these studies cannot be segregated from the previous research on wool fiber proteins. Therefore a short compilation of the knowledge in this area will be presented, especially to take into account methodological aspects and difficulties associated with the biochemical analysis of hair proteins.

The first detailed description and analysis of the whole set of native hard alpha-keratins of the human hair – recently published by two different laboratories – has provided new evidence for the already widely accepted realization that these proteins represent a distinct subclass of epithelial cytokeratins which is highly conserved in mammals. They seem to be generally involved in the formation of hardened cornified structures and may therefore be regarded as molecular markers for hair/nail type differentiation.

Similar to cytokeratins, the hard alpha-keratins can be divided into two characteristic type I and type II subfamilies, each containing four individual members which are encoded by mRNAs of their own. The unambiguous identification of the whole set of proteins by gel electrophoretic methods requires sophisticated focusing conditions which have also enabled it to be shown that the different proteins undergo an increased phosphorylation during hair maturation. Reassociation studies in which collectively separated and solubilized type I and type II proteins were combined in vitro, revealed their capacity to assemble into 8–10 nm filaments provided, however, the reassociation conditions took into account the high cysteine content of the proteins. The presence of four protein subunits in each of the two subfamilies is indicative of the formation of an equal number of distinct keratin pairs, and preliminary immunohistochemical studies with antibodies recognizing either the basic or the acidic proteins in Western blots suggest that the oppositely charged proteins appear coordinately in the keratogenous zone of the forming hair shaft.
TRENDS IN HUMAN HAIR GROWTH AND ALOPECIA RESEARCH

These new insights in the field of hard alpha-keratin composition, synthesis and localization raise a variety of new questions. It can be predicted that the strategy for the resolution of these questions will certainly involve recombinant DNA techniques to elucidate both the nucleotide and amino acid sequences of the different hard alpha-keratins and their respective mRNAs or genes. These will provide an arsenal for the generation of highly specific gene probes and antibodies which in turn will be a prerequisite to further unraveling of the complex differentiation pathways of the hair from the hair follicle germinative cells.

INTRODUCTION

The hair develops from a morphologically complex follicular structure which can be divided into three main parts: the outer root sheath, the inner root sheath and the hair itself. The outer root sheath which is continuous with the interadnexial epidermis, constitutes the outermost wall of the hair follicle and is surrounded by the connective tissue sheath. The inner root sheath consists centripetally of three concentric layers: Henle’s layer, Huxley’s layer and the inner root sheath cuticle. Finally the hair shaft is built up of the hair cuticle, the cortex and, depending upon species, localization and developmental stage, the medulla. The constituents of both the inner root sheath and the hair fiber arise from a germinative pool of matrix cells located in the club-shaped hair bulb which encloses the dermal papilla in a cavity at its base (for a detailed description of the hair follicle anatomy, see references 1 and 2). Similar to the differentiation of the mammalian epidermis, the terminal differentiation of the hair can be regarded as a suicide maturation pathway, during which epithelial cells produce abundant amounts of keratin, keratinize and ultimately die.

During the past 20 years there has been an impressive accumulation of scientific literature on the proteins which are involved in the formation and differentiation of the hair. It must, however, be emphasized that most of our present knowledge in this field has been a direct consequence of demands of wool research and, in comparison, considerably less information is available about the corresponding proteins in human hairs.

Recently, however, two laboratories – that of Franke, in Heidelberg, and of Sun, in New York – have independently and almost simultaneously tackled this problem and further investigated the protein composition of human hair3,4. These studies form the core of this review on the keratinization of human hair. It is clear, however, that these studies cannot be segregated from the previous research on wool fiber proteins. Therefore a short compilation of the knowledge in this area is necessary, especially as it takes into account various methodological aspects and difficulties associated with the biochemical analysis of hair proteins.