Dermal-Epidermal Interactions and Hair Growth

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The hair follicle is composed primarily of dermal and epidermal tissues that develop from embryonic mesoderm and ectoderm. Tissue recombination and implantation techniques have shown that interactions between these two components play a key role in the embryonic development of follicles and the subsequent maintenance of follicles and the cyclic growth of hair [1,2]. Features of these interactions will be highlighted to reveal the nature of the inherently control mechanisms that operate within hair follicles and to provide a conceptual framework for (i) investigating the molecular basis of the control mechanisms and (ii) understanding how external factors such as steroid hormones and the immune system may modulate intrinsic follicle morphology and patterns of behavior.

The importance of the follicular dermis (the dermal papilla and confluent dermal sheath) was deduced long ago by Chase [3]. A fundamental aspect of the follicle is that whereas the dermal papilla is a permanent structural entity, the hair-producing epidermal matrix is a transitory structure induced to develop at the beginning of the anagen phase of each cycle. Embryonically the papilla originates as an apparently permanent and stable population of specialized mesenchyme cells and is involved in a series of crucial inductions or interactions to ensure that follicle development occurs. The papilla cell aggregation first instructs the epidermis to “form an appendage,” which leads to follicle plug downgrowth, then transmits the specific message “grow hair.” In this way, uncommitted skin epidermis is organized into a follicular structure and its proliferative and gene activity is modulated to undertake hair-growth activities with their specific patterns of keratinization. Although the dermal component is also responsible for determining follicle type, true interactions clearly occur because epidermis containing vibrissa papilla-induced epidermal plugs can interact with back skin dermis to organize the development of vibrissa follicles. There is evidence that these embryonic interactions, in which the papilla and dermal sheath exercise ultimate control, operate during the hair-growth cycle.

The follicular response to increasingly severe physical trauma to the lower follicle demonstrates the remarkable regenerative powers of the hair follicle. Provided the essential interactive components are retained, follicles can recover to produce hairs after gross injury as also occurs, for example, after withdrawal or suppression of inflammatory cell attack in alopecia areata. The critical requirement for hair growth is the presence of a dermal papilla. If necessary follicles can regenerate a new papilla from dermal sheath cells even following removal of the whole bulb and lower region of vibrissa or human terminal hair follicles.

Direct evidence of the inductive capacity of the dermal papilla from several follicle types, including human papillae, has been revealed by implantation studies. Implanted papillae or cultured papilla cells can (i) induce epidermal matrix from outer root sheath cells and hair growth in deactivated follicles, (ii) induce the formation of new follicles when recombined with skin epidermis even from non-hair-bearing sites, and (iii) specify the type of follicle, and thus fibre type, that develops. A prerequisite for these interactive sequelae is that the papilla cells should form aggregations and that direct papilla/epidermal contact is maintained. Under these conditions adult papilla cells transmit the embryonic messages “develop an appendage” and “grow hair,” thus inducing the expression of new patterns of keratinocyte proliferation and gene activity.

Basic conclusions from these findings are that the dermal papilla and the dermal sheath (i) act as a functional unit, (ii) retain embryonic properties, and (iii) interact with and control the proliferative and differentiative behavior of the epidermal component of the hair follicle. In relation to the hair cycle, as discussed elsewhere [1,2], one could extrapolate that papilla activity is implicated in the initiation of proanagen, the duration of anagen (which can be extended following wounding of the papilla), and determining the size of the epidermal matrix and the physical characteristics of the hair fiber. In turn, dermal sheath cells could act as a cell reservoir to maintain and help regulate papilla size and play a role in guiding follicle downgrowth and follicle reconstruction during proanagen by interacting with follicular epidermis to form and maintain the outer root sheath.

The recent suggestion that hair follicle epidermal stem cells may be located in the bulge region of the follicle, rather than residing in the epidermal germ at telogen, has added new refinements to thoughts on how the papilla interacts with follicular epidermis [4]. That papilla cells exert a stimulatory effect on epidermal cell proliferation is not in doubt, as has been shown in cell-culture studies [5], and this approach should reveal the molecular identity of the factors involved in intrafollicular interactions.

REFERENCES


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