



Review Article

Mechanisms Involved in Human Hair Growths Relevant for Regenerative Medicine Therapies

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Abstract

Hair forms a barrier to protect the skin from external insults and keep the body from temperature loss. Human hair, especially scalp hair, has important ornamental functions essential for social communication and well-being. Hair regeneration depends on activating hair follicle stem cells (HFSCs). As the hair follicle (HF) is an integral part of the skin, its growth, and the activity of HFSCs are regulated by various nearby cells of the HFSC niche in the skin. The component cells of the HFSC niche are categorized into three groups according to their functions: signaling, sensing, and message-relaying. This paper reviews how HFSC activity is regulated by different signaling cells and how sensing and message-relaying cells help HFs to initiate a regenerative attempt in the face of local injury and external environmental changes. Also, on diseased states, a focus is put on how the pathological changes of the niche lead to dysregulated hair growth. In addition, how the influx or emergence of non-preexisting cells within the HFSC niche affects hair growth and depletes HFSCs. Finally, it highlights the therapeutic implications of niche pathology intending to prevent hair loss and promote growth.

Keywords: Hair growth; Follicle; Regeneration; Wnt; β -Catenin; Stem cells; Perivascular niche; Alopecia.

Abbreviations: AGA: Androgenic alopecia; ALP: Alkaline phosphatase; APM: Arrector pili muscle; bFGF: Basic fibroblast growth factor; BIO: (2'Z,3'E) Bromindirubin 3'oxime; BMP: Bone morphogenetic protein; CK15: Cytokeratin 15; CK19: Cytokeratin 19; Dkks: Dickkopfs; DP: Dermal papilla; DPSCs: Dermal papilla stem cells; Eda-A1: Ectodysplasin; EGF: Epidermal growth factor; FGF: Fibroblast growth factor; GSK3: Glycogen synthase kinase 3; HF: Hair follicle; HFSCs: Hair follicle stem cells; HGF: Hepatocyte growth factor; HSC: Hair stem cells; IGF1: Insulin-like growth factor 1; IGFBP1: Insulin-like growth factor binding protein 1; IL6: Interleukin 6; MCSF: Macrophage colony-stimulating factor; MCSFR: Macrophage colony-stimulating factor receptor; MSCs: Mesenchymal stem cells; ORS: Outer root sheath; PDGF: Platelet-derived growth factor; PDGFR α : Platelet-derived growth factor receptor alfa; PDGFR β : Platelet-derived growth factor receptor beta; PGD2: Prostaglandin D2; PGE2: Prostaglandin E2; SCs: Stem Cells; Shh: Sonic hedgehog; α -SMA: α -smooth muscle actin; TGF β 1: Transforming growth factor beta1; TNF: Tumor necrosis factor; VEGF: Vascular endothelial growth factor; WIHN: Wound-induced hair neogenesis; Wnt3a: Wingless-type MMTV integration site family, member 3A

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