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Indo-US scientists decode hair loss at molecular level, paving way for regrowth without transplants

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Researchers identify dormant signals, not dead follicles, as the true cause of hair loss

Scientists have mapped the complete molecular network that controls human hair growth, offering what may be the clearest path yet to restoring hair without surgery, drugs, or transplantation. Published in Stem Cell Research & Therapy, the review reframes androgenetic alopecia (AGA)—the most common form of hair loss—not as an irreversible condition, but as a breakdown in regenerative signalling that can potentially be reversed. This study is among the first to integrate stem cell biology, gene therapy, and molecular signalling into a unified strategy for treating AGA.

Developed by a multidisciplinary team from India and the United States with lead contributions from Indian researchers at The Esthetic Clinics (**TEC**) and the QR678 Research teams in Mumbai, the paper synthesises decades of hair biology into one unified model of how follicular cycles function, and where regenerative treatment may begin.

The paper centres on five key molecular pathways—**Wnt/?-catenin, Sonic Hedgehog (Shh), Bone Morphogenetic Protein (BMP), Notch**, and **AKT/MAPK**—that collectively manage the hair follicle lifecycle. In AGA, the communication between these pathways breaks down, particularly with Wnt suppression and BMP overactivation, causing follicles to fall into dormancy.

The research outlines multiple therapeutic strategies to biologically “reset” the follicle: Wnt activators to reignite growth, BMP inhibitors to lift molecular suppression, gene-editing tools like CRISPR to correct misfiring signals, and stem cell therapies to rebuild a supportive microenvironment. Some of these treatments have already shown success in lab-grown tissue and animal models, and early clinical trials are expected to begin within the next two years.

The $4 billion global hair loss treatment market is largely dominated by maintenance-based solutions like minoxidil, finasteride, and transplants—none of which address the root biological cause. This research offers a scientific roadmap that, if brought into clinical practice, could shift treatment from external symptom management to internal cellular regeneration.

While safety, clinical validation, and personalisation remain the next steps, the study lays the foundation for a regenerative approach that may one day eliminate the need for cosmetic intervention altogether. It also reflects a growing trend in global

science, where Indian researchers are helping lead the charge in molecular and regenerative innovation.