Study sheds light on regulation of hair growth across the entire body

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Study findings may lead to new ways of addressing both balding and unwanted hair growth. public domain/Pixabay

To paraphrase the classic poem, no hair is an island entire of itself.

Instead, University of California, Irvine scientists have discovered that all hairs can communicate with each other and grow in coordination

across the entire body. This is regulated by a single molecular mechanism that adjusts by skin region to ensure efficient hair growth - so no bald patches form - and enable distinct hair densities in different body areas.

In animals, this regulatory process is important for survival in the wild. In humans, these findings could lead to new ways of addressing both balding and unwanted hair growth - and further understanding of how regions of faster and slower regeneration work in coordination in other fast-renewing tissues, such as the intestines and bone marrow.

For the study, the researchers used the first mouse model of poor hair growth to analyze human-like hair behavior that leads to baldness. Their results appear in *eLife*, an open-access journal focusing on the life and biomedical sciences. UCI's Maksim Plikus, assistant professor of developmental & cell biology, and Qing Nie, professor of mathematics, led the effort. Ji Won Oh from Plikus' lab and Qixuan Wang from Nie's lab contributed equally to this work.

How skin regions communicate

The researchers focused on the interaction of the Wnt signaling pathway, which is important in embryonic development and regeneration, and bone morphogenetic proteins, which are hair growth inhibitory factors.

While previous studies have shown that Wnt-BMP signals regulate hair growth in certain body areas, it was not known how different skin regions communicate with one another to coordinate hairs across their borders. By combining expertise in mathematical modeling from Nie's lab and expertise in skin studies from Plikus' lab, Wnt-BMP regulation was found to be ubiquitous across all skin.

"In analogy with languages spoken in two neighboring countries, it was

unclear how the back skin 'talks' with the belly skin to coordinate the tasks of growing hairs," Plikus said. "We showed that although different signaling 'dialects' may exist between belly and back skin, for instance, all hairs can understand one another through the use of similar 'words' and 'sentences.'"

The roots of hair growth problems

A breakdown of this complex signaling could uncover the roots of human hair growth irregularities and point to solutions.

For example, common male pattern baldness affects frontal and crown regions but not the back of the head. In adult humans, messaging among scalp hairs appears to stop, and every hair follicle is thought to grow independently.

"If communication between nonbalding and balding regions can be reactivated, hair growth signals can then start spreading across the entire head skin, preventing regional baldness," Plikus said.

"Just like scalp skin can show hair growth deficiency, skin in other body sites - such as the face, arms and legs - can often show excessive hair growth that can be cosmetically undesirable," he added. "Our findings suggest that increased signaling crosstalk among hair follicles could be one major reason for this."

What's next?

Plikus said that Wnt and BMP signaling activities can be regulated pharmacologically. "Our study identified the types of Wnt-BMP signaling levels that are very favorable for hair growth and the types that prevent it," he said. "It provides the road map for optimizing Wnt-BMP

levels to achieve enhanced hair growth."

He added that the findings point toward additional signaling factors - besides Wnt and BMP - positively correlated with robust hair growth. Studying these will be the researchers' next step.

Nie noted that laboratory experiments can be insufficient to study complex biological functions, such as hair growth across the entire skin. "In such cases, mathematical modeling can greatly assist in the discovery process," he said. "Our new mathematical model predicted details of signaling communications between hairs, otherwise difficult to reveal with standard biological experiments alone."

More information: Qixuan Wang et al. A multi-scale model for hair follicles reveals heterogeneous domains driving rapid spatiotemporal hair growth patterning, *eLife* (2017). DOI: 10.7554/eLife.22772

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