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PRESS RELEASE

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From dinosaurs to birds: the origins of feather formation

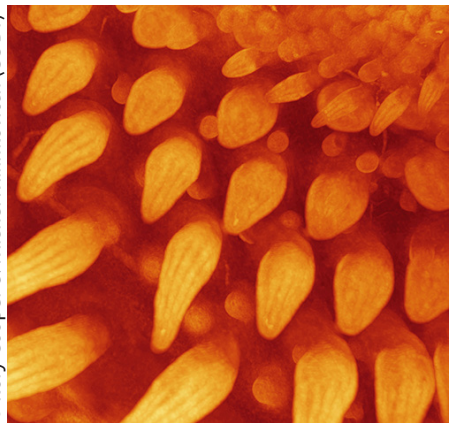
UNIGE scientists reveal the key role of specific genes in feather development, providing insights into their evolution from dinosaurs.

Feathers, essential for thermoregulation, flight, and communication in birds, originate from simple appendages known as proto-feathers, which were present in certain dinosaurs. By studying embryonic development of the chicken, two researchers from the University of Geneva (UNIGE) have uncovered a key role of a molecular signalling pathway (the Shh pathway) in their formation. This research, published in the journal *PLOS Biology*, provides new insights into the morphogenetic mechanisms that led to feather diversification throughout evolution.

Feathers are among the most complex cutaneous appendages in the animal kingdom. While their evolutionary origin has been widely debated, paleontological discoveries and developmental biology studies suggest that feathers evolved from simple structures known as proto-feathers. These primitive structures, composed of a single tubular filament, emerged around 200 million years ago in certain dinosaurs. Paleontologists continue to discuss the possibility of their even earlier presence in the common ancestor of dinosaurs and pterosaurs (the first flying vertebrates with membranous wings) around 240 million years ago.

Proto-feathers are simple, cylindrical filaments. They differ from modern feathers by the absence of barbs and barbules, and by the lack of a follicle—an invagination at their base. The emergence of proto-feathers likely marked the first key step in feather evolution, initially providing thermal insulation and ornamentation before being progressively modified under natural selection to give rise to the more complex structures that enabled flight.

The laboratory of Michel Milinkovitch, professor at the Department of Genetics and Evolution in the Faculty of Science at UNIGE, studies the role of molecular signaling pathways (communication systems that transmit messages within and between cells), such as the Sonic Hedgehog (Shh) pathway, in the embryonic development of scales, hair, and feathers in modern vertebrates. In a previous study, the Swiss scientists stimulated the Shh pathway by injecting an activating molecule into the blood vessels of chicken embryos and observed the complete and permanent transformation of scales into feathers on the bird's feet.



At the 12th day of incubation, feather buds exhibit longitudinal domains of cell density that correspond to the barbs of the future down feather.

High resolution pictures

Recreating the first dinosaur proto-feathers

"Since the Shh pathway plays a crucial role in feather development, we wanted to observe what happens when it is inhibited," explains Rory Cooper, a postdoctoral researcher in Michel Milinkovitch's lab and co-author of the study. By injecting a molecule that blocks the Shh signaling pathway on the 9th day of embryonic development – just before feather buds appear on the wings – the two researchers observed the formation of unbranched and non-invaginated buds, resembling the putative early stages of proto-feathers.

However, from the 14th day of embryonic development, feather morphogenesis partially recovered. Furthermore, although the chicks hatched with patches of naked skin, dormant subcutaneous follicles were autonomously reactivated, eventually producing chickens with normal plumage.

"Our experiments show that while a transient disturbance in the development of foot scales can permanently turn them into feathers, it is much harder to permanently disrupt feather development itself," concludes Michel Milinkovitch. "Clearly, over the course of evolution, the network of interacting genes has become extremely robust, ensuring the proper development offeathers even under substantial genetic or environmental perturbations. The big challenge now is to understand how genetic interactions evolve to allow for the emergence of morphological novelties such as proto-feathers."

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