Coming out of their evolutionary shells

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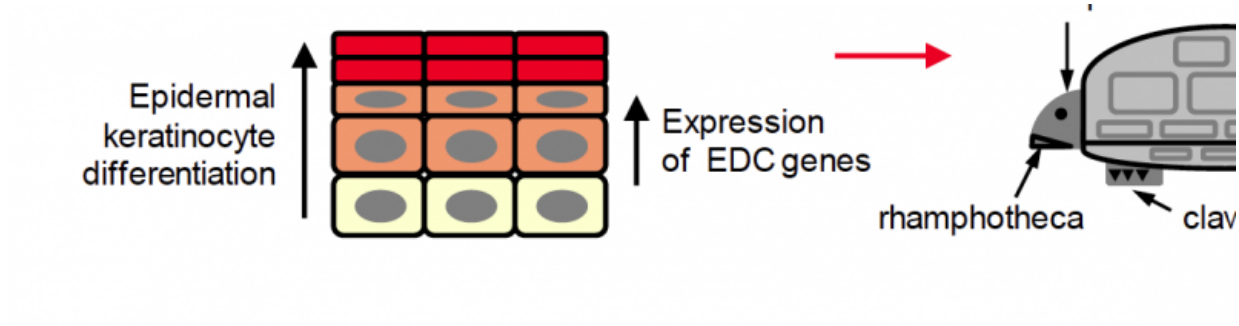


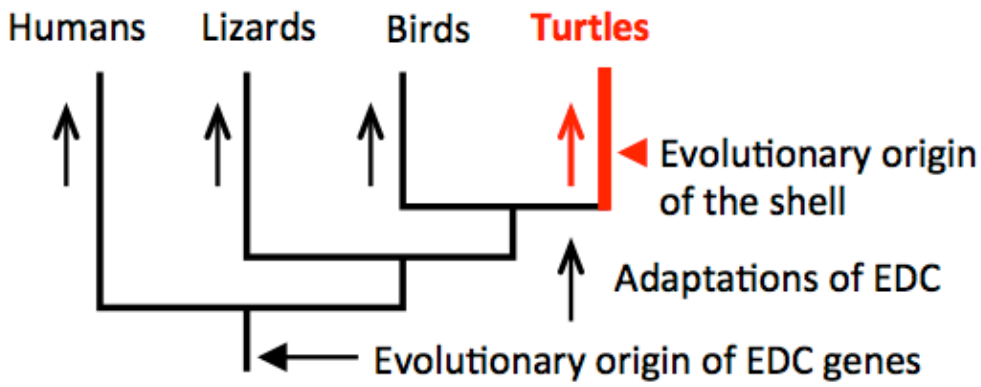
Much like other specialized skin structures of turtles, the scutes of the shell are produced by epidermal keratinocyte differentiation, as a special set of EDC genes are upregulated to make structural proteins while cells are passively moved toward the skin surface; ultimately keratinocytes undergo cornification, a mode of programmed cell death that generates rigid and interconnected cell corpses. Credit: Leopold Eckhart, Medical University of Vienna

One of the wonders of evolutionary innovation in animals is the turtle shell, which differs from any other reptilian defense adaptation, giving up teeth or venom in exchange for an impenetrable shield.

Now, corresponding author and Medical University of Vienna professor Leopold Eckhart and colleagues, in a study published in the advanced online edition of *Molecular Biology and Evolution*, performed the first comprehensive study of the genes that control the hard cutaneous layers of the shell in the North American painted turtle and other turtles.

The results of this study suggest that the evolution of turtles, separated from their nearest reptile relatives by 250 million years, involved unique adaptations of genes that are clustered within a chromosomal locus known as the Epidermal Differentiation Complex (EDC). EDC genes have originated in the first fully terrestrial tetrapods and later contributed to the evolution of claws in reptiles and feathers in birds.

In turtles, many of the EDC genes have evolved to code for proteins that can be efficiently cross-linked to harden the skin component of the shell. Moreover, beta-keratin genes within and outside of the EDC have acquired specific expression in the scutes of the turtle shell. Molecular phylogenetic analyses lead the authors to hypothesize that these specialized shell beta-keratins have evolved from components of the hard claws in primitive reptiles.



The results of this study suggest that the unique skin morphology of the turtle shell evolved by adaptations of genes located in the Epidermal Differentiation Complex (EDC), a gene cluster that is present in all fully terrestrial tetrapods and

also contributes to the defense functions of human skin. Credit: Leopold Eckhart, Medical University of Vienna

Remarkably, the basic organization of the EDC gene cluster is shared between turtles and humans due to inheritance from a common ancestor that lived approximately 310 million years ago. Previous studies have suggested that EDC genes protect against the entry of allergens and microbes through the human skin. The newly published report demonstrates that evolutionary related genes contribute to the defense against environmental insults in both humans and turtles.

More information: *Molecular Biology and Evolution*, dx.doi.org/10.1093/molbev/msv265

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