Paper challenges current hypotheses for the gain and loss of heavy pigmentation in humans over evolutionary time

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Human skin structure. Credit: Wikipedia

Popular theories of why our human ancestors gained and then lost dark skin over the course of evolution may be incorrect, according to a new paper by UC San Francisco authors, who suggest that heavily pigmented skin evolved because it forms a stronger barrier against a host of environmental challenges. Because deeply pigmented skin requires more energy to produce, they propose, our ancestors shed some of these pigments through natural selection as they moved north and needed less protection against these threats.

"Work in our lab has shown that darkly pigmented skin has far better function, including a better barrier to water loss, stronger cohesion, and better antimicrobial defense, and we began to ponder the possible evolutionary significance of that," said Peter Elias, MD, professor of dermatology. Elias co-authored the new paper, published in the June 21, 2016 online issue of the *American Journal of Physical Anthropology*, with his wife and frequent research collaborator Mary L. Williams, MD, clinical professor of dermatology at UCSF.

Many anthropologists hold that heavy pigmentation arose in our ancestors either to protect them from skin cancer or to prevent the breakdown of folic acid, an important nutrient that resides in the skin's blood vessels. Folic acid deficiencies are associated with congenital anomalies in offspring. Both of these putative protective functions would have arisen in response to heavy doses of the sun's ultraviolet (UV) rays as our newly hairless ancient ancestors moved out of the jungle and onto the open savannah.

On the other hand, as our human ancestors migrated north from Africa, many theories propose, their skin became lighter to allow more UV light to be absorbed by the skin, because a portion of the UV spectrum of light is necessary for the production of vitamin D in the skin.

In the new paper, Elias and Williams point out the potential flaws in these popular hypotheses.

For example, the peak incidence of the most common form of fatal skin cancer occurs above the age of 70. Because ancestral humans did not live nearly that long, and because this age is well after peak reproductive years in any case, the authors argue that natural selection is unlikely to have favored the stronger cancer protection afforded by dark skin. Although folic acid is critical for normal development, Elias said, the type of UV rays that destroy this nutrient rarely penetrate the skin down to the blood vessels where it resides. Moreover, the incidence of significant congenital malformations from folic acid deficiency is low, and unlikely to have influenced natural selection for additional pigmentation.

As for vitamin D production, while reduced exposure to UV rays may have played a role in the evolution of the extremely light skin found in residents of the northernmost areas of Europe and Asia, Elias and Williams propose that the moderate pigment reduction seen in Central European and Asian populations did not evolve to support additional vitamin D production. In support of this proposition, they cite studies by other researchers showing that even darkly pigmented individuals, though better protected from UV light, are still quite efficient at producing vitamin D.

As an alternative hypothesis to the evolution of dark pigmentation on the African savannah, Elias and Williams lay out largely overlooked benefits of dark skin: a more efficient permeability barrier, more cohesive and mechanical strength, and superior antimicrobial defense, a key basis for which is lower pH at the surface of darkly pigmented skin.

Previous research by Elias and colleagues found that the pH of skin in darkly pigmented individuals is substantially lower than that of their fair-skinned counterparts—the surface of dark skin is more acidic. This higher acidity increases protection against pathogenic microbes while also promoting increased production of molecules critical for moisture retention, for physical strength and cohesion, and for warding off inflammation, he said.

The new paper also proposes that pigmentation was lost in central European and Asian populations because a pigmented skin barrier, which is metabolically expensive to produce, became less important. "It's all about diverting precious resources towards the most urgent requirements," Elias said, a concept known in medicine as metabolic conservation.

As ancestral humans moved northwards from Africa into Europe and Asia to cooler and more moist environments, they began donning clothing, which provides a partial barrier. Elias and Williams theorize that the enhanced barrier function provided by dark skin became less critical. At the same time, as they entered cooler climates, modern humans' need to stay warm became more critical. Evolution would have driven a reduction in the production of intense pigmentation under such conditions, Elias said, offering intriguing examples of pigment reduction in modern humans under metabolic stress: lactating women and growing children display paler skin than that seen in individuals who have fewer metabolic demands.

Elias said that his evolutionary ideas are deeply informed by his many years of practicing dermatology as a physician at the San Francisco VA Medical Center, a UCSF partner hospital. "It helps to have knowledge of the skin when you're exploring these hypotheses," he said. "Through publications like this, addressed to non-dermatologists, we're trying to get people in other sciences to take the skin seriously—it's been trivialized since the time of Aristotle."

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