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HOW WE GET OUR SKIN COLOR

Full Animation

Skin covers all our bodies, but its color varies from person to person. To understand why, we need to peer inside its layers.

Skin cells and their allies — hair, sweat, and oil glands — form a first line of defense from the environment. Skin's three main layers are each a distinct community of cells with different jobs. To see what gives skin its color, we need to focus on the outermost layer — the epidermis — and two important cell types: keratinocytes and melanocytes.

The keratinocytes are the cells that form the surface of the skin and are on the frontline for taking insults from the environment. Deeper down in the epidermis, right at the base of the layer, we find the melanocytes. These star-shaped cells produce the important pigment melanin.

Let's zoom inside a melanocyte to see how this works. Melanin is produced inside what look like spheres throughout the melanocyte. These are the melanosomes. Chemical reactions inside melanosomes turn the amino acid tyrosine into melanin. The proportion of two main forms of melanin produced (a reddish-yellow type versus a black-brown type), the total amount of melanin in each melanosome, and the number of melanosomes in the epidermis all vary from person to person and determine their skin color.

Melanosomes are the melanin factories inside melanocytes. But for melanin to do its job, melanosomes need to be transported to the keratinocytes via the melanocytes' long projections.

Inside the keratinocytes, some melanosomes form a cap around the cell nucleus. The melanin inside the melanosomes absorbs the ultraviolet energy from sunlight, reducing the amount of ultraviolet radiation that reaches the nucleus and, in particular, the DNA inside the nucleus. Ultraviolet radiation can cause mutations in DNA that can lead to cancer. When ultraviolet radiation increases, melanin production increases, and more melanosomes are delivered to keratinocytes.

Most people can adjust to greater exposure to the sun by turning up melanin production and tanning. But their genetic inheritance determines both the baseline color of their skin and how much it can tan.

WHAT IS SKIN?

How Is Vitamin D Made?

VIDEO CLIP: Nina Jablonski explains the importance of UVB radiation in the synthesis of vitamin D

[NINA JABLONSKI:] UV light is not all bad. In fact, the small portion of it known as UVB is critical for the synthesis in our bodies of vitamin D — a process that starts in the skin. Without vitamin D, humans cannot absorb calcium from our diet, to build our bones and for a healthy immune system.

Back when all our ancestors lived close to the equator, there was no problem getting enough UVB through dark skin to make the vitamin D needed. But then some populations started moving north, where the UV striking Earth's surface is much weaker.

In northern latitudes, dark skin makes it hard to produce the vitamin D that human bodies really need. The consequences of vitamin D deficiency include rickets — a bone development disease that can cripple the young.

WHAT IS MELANIN?

How Do Genes Determine Skin Color?

VIDEO CLIP: Rick Kittles describes variations in the *MC1R* gene in different populations

[RICK KITTLES:] So, if we look at humanity as a whole, right? The set of genes that are important for skin and eye and hair color, there are gonna be a large number of them, I believe. And also, the effects of those genes are gonna vary across populations.

[NINA JABLONSKI:] Yeah.

[KITTLES:] So, right now, we really don't know the — the number exactly of the number of genes that impact skin color. But we have over 20 that have been identified that play some role. And I think that that is the sorta the next phase for the research, is to really see the true number of genes, and then also the effects of those across populations.

And, in particular, I could, I could give you an example. An important gene — *MC1R*, the melanocortin 1 receptor, which codes for a protein which is involved in the switch from the production of pheomelanin to eumelanin.

And we know pheomelanin is the reddish-yellow pigment that's produced by cells in our body called melanocytes. And then, the eumelanin is the brown-black pigment. So, some populations — many African populations — produce a lot more eumelanin than pheomelanin, while other populations produce more pheo, the lighter pigment.

So, *MC1R* is an important gene for that switch. When we look at *MC1R* within African populations, we don't see a lot of diversity. We find that, that there was evidence of this selective pressure that created this constraint in that region because individuals with that particular DNA sequence in Africa have darker skin. And it was important for survival in Africa.

Think about, in particular, the tropical regions of Africa, where there's UV-intense, very high sunlight. And so, there was an important role that eumelanin, or darker skin, played in the survival of those populations.

HOW DOES SUNLIGHT CAUSE TANNING?

What Happens When We Tan?

VIDEO CLIP: Zalfa Abdel-Malek explains what happens when we tan

[ZALFA ABDEL-MALEK:] So, of course, if you ask anybody, "Who gets the sunburns?" — people with very fair skin that are highly sensitive to UV. It's like, you take somebody with intermediate skin pigmentation, somebody with light skin color, expose them to the same amount of UV, the same duration: one person tans, one person burns.

So the burn is because of a very potent inflammatory response that happens in the skin, causes the keratinocytes, which are the major epidermal cells, to undergo apoptosis, or cell death. And then you see the peeling that comes. The skin peeling is you're really peeling off your dead cells. And this is not a healthy response, obviously. Yeah, no, you're killing the cells.

A dead cell is a dead cell. It's not gonna do anything. You can always make more of them. But the danger is the ticking bomb that stays in the skin, doesn't die and doesn't repair the damage, and have mutations in important genes that can ultimately cause skin cancer.

Well, the tanning response is, you know, people that are exposed to high levels of UV, this is, tanning is really a response to DNA damage. So DNA damage, or inflammation in the skin, can stimulate increased pigmentation. So you're making more melanin, or more eumelanin.

So you're making this, this protective product there. This would help you to resist damage from subsequent sun exposures. This is, this is what we see even on experimental level, that, after UV radiation, what happens is, the cell needs to deal with the damage first because it, it either can die, or it can keep the damage and have a mutation. So the best thing is to repair itself. And then, you see that, at a later time point, production of more melanin.

So it's, it's kind of like the second line of defense. The first line of defense is DNA repair. The second line of defense is increased pigmentation and, of course, increased thickness of the epidermis, to prevent excessive UV damage.