Answers in Depth, Vol. 16, (2021), pp. 13–17.
https://assets.answersingenesis.org/doc/articles/aid/v16/what-color-adam.pdf

What Color was Adam?

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Humans around the world are diverse with different hair colors, eye colors, and skin shades, among many other traits. Yet, the Bible teaches that we are all descendants of Adam and Eve. This raises interesting questions regarding the origin of the various colors and shades. For example, we might wonder what Adam and Eve looked like? Or, how could we have so much variation from just two original parents?

When I was in high school, I was interested in genetics. For a science fair project, I crossed a white mouse with a brown one to see what color the offspring would be. All the mice in the next generation were gray. This was a surprise. I crossed the gray mice thinking that it was codominance as occurs with chocolate labs. The mice from the second cross were not at all what I expected. They had a white mouse and a brown mouse, as anticipated. But there were also white-and-brown and white-and-gray splotched mice. There was also a cinnamon-colored one as well as one that was yellow. Totally confused, I gave up the mouse breeding project in favor of a computer simulation model. That experience left me with a lasting curiosity about the biology and genes responsible for color.

Only Skin Deep

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Skin pigment is primarily determined by the amounts of two different color pigments: eumelanin and pheomelanin. Eumelanin is a very-dark-brown, almost-black color, while pheomelanin is reddish brown. Both pigments are made by special cells called *melanocytes*. While the melanocytes produce these pigments, they are released and then taken up by another type of cell in the skin called a *keratinocyte*. There are many more keratinocytes than melanocytes in skin—about 36 to 1. Importantly, regardless of skin color, all people have about the same number of melanocytes. That means that factors other than the number of melanin-producing cells are responsible for skin pigmentation. This involves several different processes and genes, even though there are only two color pigments. For example, the pigment must be taken up by cells as well as produced. A defect in either process would result in less pigmentation. For those with lighter skin, contributions from connective tissue and blood impact the color as well. For example, light skin will become pink to red with increased blood flow or even whiter or a blue/purple color when blood flow decreases or becomes constricted.

Biochemical Factors

Scientists have discovered that an important step in the production of melanin requires a protein called the melanocortin 1 receptor (MC1R). This protein determines which color pigment (eumelanin or pheomelanin) will be produced. The MC1R protein is on the surface of the cell, where it binds to another protein called melanocyte-stimulating hormone (MSH). This hormone is produced in the pituitary gland, which is a small structure near the center of the bottom of the brain. Mutations in both the hormone and the receptor have been linked to changes in the amount and type of melanin that is produced. For example, individuals with a loss of function mutation for MC1R may not only have red hair and fair skin but also skin that would not tan very well. Such individuals make little if any eumelanin but instead make the pheomelanin, which is the reddish-brown pigment. Albinism, where little if any pigment is made, results from mutations in another gene that prevents pigment production altogether.

Importantly, the darker eumelanin can absorb UV light, while the lighter pheomelanin does not. Typically, melanocytes respond to increased UV light by producing more eumelanin, which is what causes skin to become darker during the summer when people are exposed to more sunlight. In some cases, the melanocytes will produce the pheomelanin instead, which will make small tan spots or freckles. Melanin absorbs UV light and so protects the body from degradation of folates. Folic acid, a B vitamin, has roles in several important body functions, including red-blood-cell production, DNA production, and prevention of neural tube defects during the early stages of pregnancy. Therefore, melanin plays an important role in protecting this vital molecule. Additionally, melanin protects against UV-induced skin damage and cancer. UV light is not all bad, however. In fact, we need UV exposure to produce vitamin D. The trick is to absorb enough UV light to make vitamin D without getting so much that it eliminates folates or causes cancer.

While people in Africa tend to show a high degree of genetic diversity overall, there is a lack of diversity of the MC1R gene. In contrast, in parts of the world where individuals have light skin, there are many different mutations and polymorphisms of MC1R, all of which lead to decreased eumelanin production. Apparently, selective pressure for higher melanin production near the equator (due to protection of folates and preventing cancer) maintains the high melanin-producing form of MC1R. In contrast, away from the equator where UV exposure is reduced, no such selection pressure exists. Without selection pressure, more mutations and polymorphisms (in MC1R and other genes) are propagated and maintained because there is no pressure to eliminate them (Harding et al. 2000). In other words, where UV light is more intense, it is necessary to produce more melanin. Where the UV light is less intense, the amount of melanin produced is less critical and therefore varies widely with fewer detrimental effects.

While there may be some advantage to lighter skin that is able to absorb more UV light in areas away from the equator, there is no strong evidence that the advantage is significant enough to result in selection. Therefore, while lighter skin may be *selected against* close to the equator where UV light is intense, lighter skin is *not selected for* in areas away from the equator where UV light is less intense. The result is greater variation further from the equator due to neutral selection and genetic drift.

Additional evidence that darker skin may have been the norm earlier in human history comes from "Cheddar man." The remains of an ancient human in Great Britain were studied to obtain DNA sequences. The results were interpreted to indicate that this individual likely had blue eyes and very dark skin.

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Often when people consider skin, they think in simplistic terms (red, yellow, black, white) and fail to recognize the wide range of skin tones found in humans. Across the African continent, among those who would be called "black," some are darker and some are lighter. Similarly, among those across Europe that would be considered "white," some are darker and some are lighter. These results, when taken together, would imply that Adam and Eve likely had higher levels of melanin production and thus darker skin. Since genes linked to lighter color appear to be mutations and polymorphisms with significant variability, it suggests that lighter skin colors came later among their descendants, perhaps even after Noah's flood.

Hair Color

As with skin, there are two main color pigments for hair: eumelanin and pheomelanin. These pigments are produced by melanocytes and taken up by keratinocytes that produce the hair. However, there is a role for an additional cell type, the dermal papilla cells. These cells direct the melanocytes to transfer the melanin to the keratinocytes. This adds an additional layer of complexity since alterations in control from another cell type can impact the amount of pigment ultimately taken up by the hair. As with skin, the MC1R gene is determining which of these pigments are produced. Brown hair is the second-most-common hair color globally and results from eumelanin mixed with low levels of pheomelanin. Differences in the amounts of eumelanin and pheomelanin yield multiple shades of brown. Blond hair is caused by very low levels of pigment incorporated into hair.

A loss-of-function mutation in MC1R can result in production of the red pheomelanin pigment instead of the much darker eumelanin pigment if an individual has both copies of MC1R with that mutation. However, as with most examples in biology, the actual hair color is far more complicated. MC1R is a receptor, so if the MSH hormone is mutated or lost, this will also affect the color of the hair. A very surprising result from a recent study1 was that most individuals with two MC1R variants did not have red hair; they had blond or brown hair instead. Although there is a range of factors that contribute to the amount and type of pigment found in hair, there are still only two pigments.

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A very large study of hair color genetics found that there were additional factors besides genes that contributed to the actual hair color (Morgan et al. 2018). Researchers have identified over 200 genetic variants independently associated with the full spectrum of hair color from blond to black. Besides multiple genes and many variants, other properties of hair have an impact on perceived color. For example, the rate that hair grows will ultimately impact how much melanin is incorporated into the hair. The thickness of the hair and the reflective and refractive index will also contribute to the perceived color of the hair. All these various physical properties and numerous genes work in concert to produce a broad spectrum of hair colors and types. It also explains why, even within families, there can be such a range of hair colors, especially for those with MC1R variants.

Red hair is most often associated with individuals from Ireland and Scotland. About 10% of people from these countries have red hair, and an estimated 31% of people there carry at least one of the MC1R genes for red hair. Although rarer, people with red hair can be found in many parts of the world, including Jamaica, Morocco, Iran, and China. Individuals of African descent can have red hair too. When they do, they tend to have lighter skin and freckles, as would be expected with less eumelanin production. Again, this trait is not typically found in equatorial Africa due to selective pressure against it, extremely low frequency of MC1R mutations, and the requirement of inheritance of two MC1R mutant genes to express the red hair trait.

When it comes to hair color, perhaps the most striking people are from Melanesia and the Solomon Islands. A significant number of people there have very dark skin and natural blonde hair! Although the blond hair is the same phenotype as that found in Europe, the gene involved is not the same. As noted above, the MC1R receptor gene is the one most associated with red and blond hair. However, for the Melanesians it is a completely different gene. In this case, the gene is TRYP1 (Kenny et al. 2012). The gene codes for an enzyme that is involved in the production of melanin itself. Since these individuals have dark skin, they obviously make the eumelanin pigment. It could be that the rate of melanin formation is affected rather than the amount. If so, then hair color, which is impacted by the rate of hair growth, could also be affected. This could mean that although they can make the dark pigment, it is not incorporated into hair at a rate that allows enough pigment to make the hair dark. Thus, the hair is blond.

Eye Color

Human eyes come in a range of colors. Although we typically think only brown, blue, green, and hazel, the eyes can be even more colors, including gray and amber. In very rare cases, eyes can appear red or violet. Individuals with these colors typically produce extremely low amounts of pigment, if any. The red color is from blood. The American actress Elizabeth Taylor was said to have violet eyes.

As with skin and hair, there are the same two color pigments: eumelanin and pheomelanin. However, there are at least 16 different genes that are known to contribute to eye color. The color will also appear different depending on whether the pigment is on the front layer of the iris or the back layer of the iris.

Eye color	Melanin Presence on Front Layer of Iris	Melanin Presence on Back Layer of Iris	Dominant Pigment Type
Brown	Heavy	Normal	Eumelanin
Blue	Light	Normal	Eumelanin
Gray	Even less than blue	Normal	Eumelanin
Green	More than blue eyes, less than brown	Normal	Pheomelanin/lipochrome
Hazel	More than green, less than brown	Normal	Pheomelanin and Eumelanin
Amber	Heavy	Normal	Pheomelanin/lipochrome
Red or Violet	None or extremely little	None or extremely little	n/a

Lipochrome is a yellow compound that results from breakdown products from lipids. This molecule contributes to the green and amber eye colors. Light scattering through the layers of the iris leads to the appearance of the blue color as well as green and gray. Individuals with gray eyes have additional collagen fibrils in the iris that make the eye appear gray.

Mutations and polymorphisms in OCA2, a gene involved in melanin production in the eye, have been linked to reduced melanin presence in the front layer of the iris. Such changes result in eye colors other than brown. Interestingly, individuals with blue eyes do not have mutations in OCA2. Instead, they have a mutation in HERC2, which is adjacent to OCA. Scientists believe the evidence suggests that most people with blue eyes all descended from the same individual with a mutation that knocked out Herc2 and OCA2 simultaneously (Eiberg et al. 2008). Thus, it is likely that Adam and Eve would have had brown eyes, as it is clearly a variety of mutations and polymorphisms that contribute to non-brown eye colors due to alterations in the amount of melanin in the outer layer of the iris.

Although rare, individuals with dark skin can have eye colors other than brown. Such people may have green or even blue eyes. Such unusual trait combinations underscore the multiple layers of genes that are involved in coloration. While several gene products are involved in the production of melanin and pheomelanin, others are required for placement. It is insufficient to make a pigment and not incorporate it in the desired target. People with dark skin clearly make melanin, but if they have blue eyes or blond hair, then the pigment is just not incorporated into the iris or hair appropriately. That such individuals exist provides support for the dark skin and blue eyes of "Cheddar Man." Further, this again provides strong evidence that Adam and Eve likely had dark skin, dark hair, and brown eyes.

Can Two Original Parents with Two Alleles Generate Wide Variation?

Through middle and high school, students are frequently presented with simple, straightforward examples to learn about inheritance. With presentations on Mendel's peas and the dominant/recessive traits of wrinkled/smooth, green/yellow, and tall/short, the complexity of apparently simple traits like eye and hair color is underappreciated. Examples such as ABO and +/- blood groups serve to reinforce a simplistic (and unrealistic) view of genetics. When confronted with traits with a wide range of possibilities (hair and eye color, for example), they are likely to default to those simple explanations and not have good answers. For a long time, I assumed that Adam or Eve had brown eyes while the other had blue. Such an explanation completely breaks down when the possible traits exceed four. Since each person can only have two alleles for any given gene, where could the others come from?

Knowing that traits which seem simple may involve many different gene products and receive contributions from non-genetic factors paints a very different picture. Multiple mutations in multiple genes can ultimately have a similar phenotype. This is observed with blond hair, which is caused not by production of a yellow pigment but by a lack of incorporation of a dark pigment. This lack of pigment can be caused by not producing the pigment or by not sending the pigment to the proper destination at the proper rate. In either case, the result looks similar, but the process occurs by different mechanisms.

Scientific Evidence, Interpreted Rightly Will Support the Bible

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We all need to be careful of the assumptions and potential biases that we have when we interpret data. During my early years, I assumed Adam and Eve were light skinned because all the pictures and paintings depicting them had light-skinned individuals. As I learned more about biology and genetics, my view changed again to one of them as light skinned and the other one dark. I reasoned that to get offspring that have a range of skin shades, hair color, and eye color, it would only work if the original parents were both heterozygous for all the traits. I suspect that I am not unique in these assumptions. The danger comes, however, when such mistaken assumptions encounter scientific evidence that calls them into question. Some may reject Adam and Eve altogether instead of abandoning a false notion about them.

We are not given any information about the physical attributes of Adam and Eve, so there is no biblical basis to assume anything regarding their skin, hair, or eye color. Even though there is a broad range of skin shades and hair and eye color, multiple alleles are not required to generate the diversity. Instead, the diversity can result from differential effects along a common pathway. Thus, two dark-skinned, dark-haired, dark-eyed parents can indeed give rise to the full spectrum of colors found among humanity. Over the generations, novel phenotypes arise through mutation, corruption, and loss. Blond hair and blue eyes result from genetic mutations that persist because they are not selected against in the absence of high UV light.

Scientific evidence supports that all humans are descendants of Adam and Eve. Moreover, we are all connected to each other through our first parents regardless of superficial traits.

> *Then Peter began to speak: "I now realize how true it is that God does not show favoritism but accepts from every nation the one who fears him and does what is right.* (Acts 10:34–35 NIV)
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> *From one man he made all the nations, that they should inhabit the whole earth; and he marked out their appointed times in history and the boundaries of their lands.* (Acts 17:26 NIV)

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