Understanding what makes black pigment black

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Scientists have for the first time "unmixed" the black pigment that colors our skin and gives bananas their spots.

Researchers at The Ohio State University did the work with eumelanin, a form of melanin that produces brown or black colors.

Melanin is important to the human body: It acts as a natural sunscreen, protecting DNA from damage caused by the sun's ultraviolet rays. It also destroys free radicals in the body and keeps metal ions from harming organs.

But despite knowing all of that, scientists do not know one of the most basic things about melanin, said Bern Kohler, senior author of the study, published today in the journal *Chemical Science*.

"The most fundamental question that can be asked about a pigment is what gives it its color," said Kohler, Ohio Eminent Scholar and chemistry professor at Ohio State.

"And we don't have an answer for that. So we essentially unmixed the color black to reveal the underlying colors."

Kohler said that understanding the structure of melanin is crucial for scientific advances in medicine and materials science.

"One of the really big puzzles about melanin—and it always surprises scientists who are not melanin experts—is that we don't have a structure for melanin. Think about the DNA double helix: We had to know the structure of that double helix before we could understand what was happening with DNA. Knowing the structure is often how we make progress in science," he said.

"Eumelanin is this brown-black pigment that's in all of our skin and hair, and it's really interesting to a spectroscopist—and that's what I am—because it absorbs all the spectral components of light. This makes it attractive for solar energy and other applications where capturing all of the energy in sunlight is important."

Consider a child playing with paints and learning about colors, Kohler said. They combine yellow and blue and get green. They combine red and yellow and get orange. But combine all the colors, and the result will be a deep, muddy black.

"That's melanin," he said. "And we wanted to know what it took to make it—what small molecules of color are in it. "

Kohler's team, which included Ohio State postdoctoral researcher Christopher Grieco and graduate student Forrest R. Kohl, has been working on an answer to that question. Answering it, he said, might open the door to future discoveries that could help make better sunscreens.

To take a step in that scientific direction, the researchers created eumelanin in the laboratory. Then they used extremely short pulses of light less than one millionth of one millionth of a second in duration to look for different pigments.

Some light-absorbing materials are constructed like crystals, in a symmetric, predictable order. Melanin is not constructed that way, Kohler said. Instead, it is made up of chromophores—parts of molecules that give things their color—assembled in a seemingly random, disordered way.

To understand more about the structure of melanin, Kohler and his team examined those chromophores, then removed some using short pulses of light to see what would happen to the pigment. Would the pigment's color change, for example? Would the other chromophores fill in the gap?

"Think of it like your FM radio in your car," Kohler said. "You can tune it to many different stations because each one broadcasts over a limited range of the radiofrequency spectrum. Instead of transmitting radio waves, the melanin chromophores absorb higher frequency light waves, and we wanted to determine how much of the electromagnetic spectrum is occupied by each chromophore 'station."

"What we were asking was how many stations are out there? Within the visible spectrum are there many chromophores that absorb at different frequencies or just a few that are using most of the possible bandwidth?"

What they found, essentially, is that tuning a narrow pulse of light across the visible spectrum could knock off a few of these stations—a few chromophores—at a time, leaving behind other chromophores that absorb different colors.

"In our experiments, when we got rid of a station, we bumped into new stations," he said. "And what we saw is that these different chromophores aren't really talking to each other. They behave sort of independently from one another."

Provided by The Ohio State University

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