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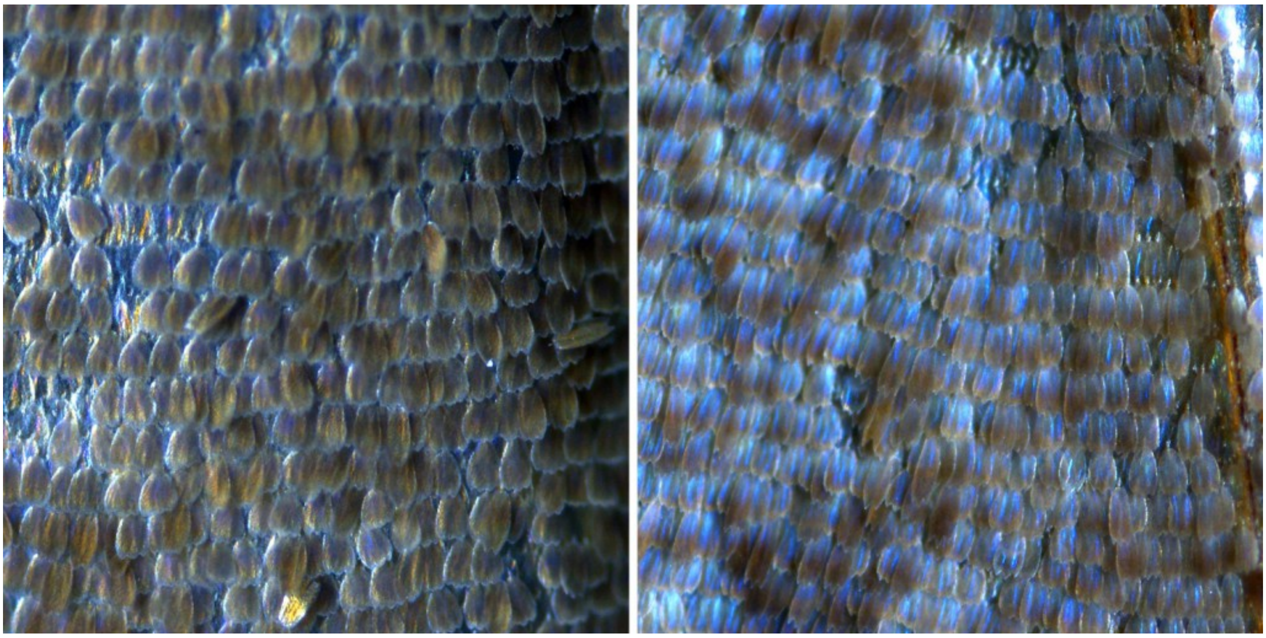
It Only Takes Six Generations to Turn a Brown Butterfly Purple

By Elizabeth Preston | August 8, 2014 9:27 am



Evolution can seem like a slow way to get things done. It took more than a billion years for Earth's life forms to try having more than one cell. In the famous *March of Progress* illustration showing an ape becoming an upright human, you can almost hear the stoop-shouldered cave guy in the middle groaning, "Hurry up already!" But all that is deceptive, because evolution is also fast. It took scientists only a few quick generations of butterflies to make a brown species turn violet. In doing so, they gained insights about color that they hope will last a little longer than their subjects' dull wings.

Nature has two ways of making colors. There are pigments, like the green chlorophyll molecules within plant leaves and the brown melanin in humans. Then there's structural color: nanoscale tricks of reflection that make surfaces appear different colors, depending on their microscopic shapes. Butterflies are masters of this.

The butterflies examined by Yale University evolutionary biologist Antónia Monteiro, physicist Hui Cao, and their colleagues were in the genus *Bicyclus*. This includes more than 80 species, most with un-showy brown wings. Two branches of the *Bicyclus* family tree, though, have evolved blue-violet stripes.

Butterfly wings have rows of two types of scales, "ground" scales and the "cover" scales that partially overlap them. Tiny ridges and ribs on these scales can produce structural color. But the scientists weren't sure how exactly *Bicyclus* butterflies produce the color violet. They also wondered how easy it is for these butterflies to evolve new structural colors. To find out, they began a breeding experiment.

In two violet-striped species, an optical analysis showed that the purple scales reflect light with a wavelength between 400 and 450 nanometers. (Visible violet light is around 400 nm, and blue around 475. Keep increasing the number—stretching those waves wider—and you'll get green, then yellow, and so on, eventually passing into red and invisible infrared waves.)

In *Bicyclus anynana*—a plain, unstriped species that's common in labs—the scales that appear brown to our eyes also reflect ultraviolet light of about 300 nm. From one butterfly to the next, there's slight variation. By breeding together butterflies that reflected the longest wavelengths, could the scientists create wings that reflected violet light?

They got their answer in just a half-dozen sets of parents and children. With each group of butterflies that hatched, the scientists chose the 15 to 30 individuals of each sex whose wings reflected the longest wavelengths. Six generations later, some butterflies were violet, reflecting light between 400 and 500 nm (with the average butterfly reflecting in the upper 300's).

This showed that structural color is both flexible and easy for one generation to pass on to the next. Although they only focused on one area of the wing (the middle of the front wing, where a purple stripe is visible in species that have it), Monteiro says the butterflies in her experiment turned violet "pretty much everywhere" on that wing surface. And, she says, even though conditions in the lab were unnatural, the experiment is a window onto how evolution can happen in nature.

"[We] allowed around 10% of the individuals of a population, with the most extreme characteristics, to reproduce," Monteiro says. Under the right circumstances, natural selection can be just as stringent. "What this experiment tells me is that if natural selection were to favor the evolution of violet color in natural populations of these butterflies, it would have been able to do it in a short amount of time." In other words, if some change in its environment suddenly made violet scales better for the brown-winged *Bicyclus*, it would have no trouble adapting.

The experiment also showed that there's more than one way to make a purple butterfly. The experimental butterflies turned violet by changing the microscopic structure of their ground scales. But one of the naturally purple-striped species makes the color using its cover scales; another species uses both scale types.

Hui Cao, the physicist involved in the study, is more interested in what tricks humans can borrow from butterfly evolution. She works on materials and devices that use their microscopic structure to manipulate light, just like butterfly wings do. Engineers would love to be able to adjust these devices to reflect whatever wavelength of light they want. "The butterflies in our artificial selection experiment also need to change color very quickly in order to survive," Cao says.

Evolution favors the insects that alter their color with the simplest tweak to their wing structure—and engineers, too, want the most efficient answers. "By observing how they do it, we can find out what the optimal solution may be," Cao says. If scientists' march of progress could happen as quickly as nature's, they'd be pretty happy.

Image: Antónia Monteiro.

Wasik, B., Liew, S., Lilien, D., Dinwiddie, A., Noh, H., Cao, H., & Monteiro, A. (2014). Artificial selection for structural color on butterfly wings and comparison with natural evolution *Proceedings of the National Academy of Sciences* DOI: 10.1073/pnas.1402770111

Thanks also to @drskyskull for a chat about optics!

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Guest • 3 months ago

"But all that is deceptive, because evolution is also fast." This article is also deceptive. The butterflies already had it in their genetics and some branches of the family already had violet. This is breeding and not the same as evolution. If people were to breed spots out of a species of dog over a few generations, that isn't evolution.

The title of the research referenced, "Artificial selection for structural color on butterfly wings and comparison with natural evolution" is much more accurate than this article's opening paragraph.

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R2D3 • 3 months ago

A friend writes: "This is evolution? I could do it in one generation given the right butterflies. And it's a wonderful example of artificial selection."

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R2D3 • 3 months ago

This colour change is only microevolution, which is really not evolution at all. Biblical creationists would say a more accurate term would be microvariation--within a created kind/baramin.

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mutantbuzzard • 3 months ago

so how many generations do it take to turn a dinosaur in to a bird?
this not evolution, it is adaption, big dif, as one is real & the other is bulliberal

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> **JoAnna** → mutantbuzzard • 3 months ago
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> Adaptation is evolution that allowed the species to survive. Arctic rabbits EVOLVED to turn white in the winter to better hide from predators. This is adaptation.
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> > **mutantbuzzard** → JoAnna • 3 months ago
> >
> > Adaptation is adaptation that allowed the species to survive. Arctic rabbits adapted to turn white in the winter to better hide from predators. This is adaptation.
> > evolution that turns dinosaurs in to chickens is bulliberal
> >
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Eräticus Mäjoricus • 3 months ago

This was very interesting. Given more generations, would it be possible to bring the butterflies wings to blue or green? Or is there limit to the amount of "stretch" this aspect has for change?

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R2D3 • 3 months ago

A friend writes: "WOW. It only takes a chameleon or octopus a few seconds to change color. EVOLUTION IS EVEN FASTER THAN WE THOUGHT."

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