Genetic Patterns of Mimicry

Heliconius butterflies show distinct wing patterns.
The two butterflies on the top row are poisonous.
The two mimicking species on the bottom row are not poisonous, but avoid predators by looking like poisonous species.

Science is about asking questions and finding ways to get answers. Scientists know the function of many genes in humans and other organisms. There are many more genes with unknown functions. How do you think researchers find out the role of a gene?

One way is by "breaking" the gene to see how that affects the organism. Joe Hanly, a butterfly researcher, describes the process like this: "Imagine you didn't know how a car works, what all the parts do and how those parts work together. You might open the hood, take a hammer, bash one of the parts, and then see how the car works. Now, if the car quits working, that wouldn't be very informative. If the car still works, with one part broken, you'd know what that part does. Let's say you bash a part with the hammer and the car starts, but it overheats. You'd know the part you broke was involved in cooling the car's engine. You have broken the radiator."

Genome editing is a way scientists can break genes by turning them off. CRISPR is one tool used for genome editing. CRISPR makes changes in the DNA, stopping the production of protein. Scientists can send CRISPR to one area in the genome and turn off one or more genes. Let's look at how genome editing can answer a biological question.

You may have learned about mimicry in elementary school. In biology, mimicry refers to an animal or plant that looks very similar to another animal, plant, or nonliving object. A caterpillar may have body colors and shape similar to twigs and branches. This helps the caterpillar hide from birds that might eat it. This camouflage is a type of mimicry. In another kind of mimicry, an organism appears very similar to a poisonous organism. This copycat appearance gives the harmless life form protection. Predators avoid it, thinking it is poisonous. Mimicry leads to our biology question: do the copycat organisms use the same gene pathways as the toxic organisms to develop unique colors and patterns?

One example is the ***Heliconius butterfly*** in South America. These colorful butterflies have bright red and black wings and look almost identical. What makes this interesting is that they don't belong to the same species. *See photo above of the two species.*

The butterflies on the top row are from a species that is poisonous or tastes awful to the local bird predators. The butterflies on the bottom row are a different species that would be tasty food for birds. Birds avoid the safe butterflies because they look so much like the toxic kind. Butterflies that look like poisonous ones are more likely to survive. Over many, many generations, the surviving harmless butterflies look more and more like their poisonous neighbors. These look-alike butterflies give biologists a unique opportunity to find the genes for mimicry.

Scientists know many of the genes that control wing traits in butterflies. Wing traits include color, pattern, size, and shape. These genes are highly conserved, which means the DNA is very similar in sequence across many butterfly species. Scientists did not know if the copycat butterflies have the same changes in wing trait genes as their poisonous neighbors. Did the safe butterflies use the same gene pathways as the toxic insects?

Scientists focused on one gene, *WntA* (pronounced went-A), that controls the light and dark coloring on the wing to answer this question. This gene controls the line patterns seen on the wings of both species. Knowing this gene, scientists thought of a way to answer their question. They used genome editing to switch off the *WntA* gene. Turning a gene off is also known as knocking the gene out. In order to knock out this gene, they would have to add CRISPR into butterfly eggs before the wings develop. How could knocking out the *WntA* gene in both species answer their question about gene pathways?

Scientists thought that if they knocked out the *WntA* gene in butterflies from both species, they would wind up with butterflies with the same wing pattern. Their reasoning follows this line of thought. If two different gene pathways led to the same wing patterns in the two species, knocking out the *WntA* gene should lead to butterflies with different patterns on the wing. If the same gene pathways regulate the wing traits in both the poison and nonpoisonous types, then changing *WntA* should lead to butterflies that still look the same. The same gene changes should cause the same change in wing pattern.

Scientists collected thousands of butterfly eggs from both species. They treated the eggs to knock out the *WntA* gene. Then they waited for the eggs to hatch. The caterpillars appeared perfectly normal. They waited for the caterpillars to grow and form cocoons. It wasn't until the adults emerged that the researchers would have their answers.

The adult butterflies were not the same. Both species showed changes in wing pattern, but they weren't the same changes at all. One species had almost no dark lines and large uneven patches of color. The other species still formed dark lines but in entirely different patterns than the expected pattern. These results told the scientists that even though the two butterflies look incredibly similar, the gene systems for that look were completely different.

The growth of wing patterns and colors in all butterflies are driven by the same forces: survival and success in finding a mate. This research suggests that many gene pathways can lead to the same color patterns in butterflies. The mimic species developed an identical color pattern to the poisonous species using different genes. This is an important answer for biologists studying the mechanisms of mimicry.