How do hummingbirds find life-sustaining nectar without sweet-taste receptor genes?

For us, sugar is a treat. For hummingbirds, it's life itself.

Even among birds, a group famous for their fast metabolisms and high energetic needs, hummingbirds are outliers. These souped-up little aerialists have evolved a unique diet to fuel their hyperbolic lifestyle; they dine almost exclusively on the sugar-rich nectar of flowers.

Here's the catch: birds, as a rule, cannot taste "sweet" the way we can. They simply don't have the taste receptors for it. To us taste might seem superficial but it evolved as an absolutely vital way to help animals tell good food from bad. Hummingbirds can taste sweet; The ability to taste sweetness is how a hummingbird knows the difference bewteen nectar — rich in the calories to keep it alive — and calorie-free water. When you walk the metabolic tightrope that is hummingbird life, one mistake about what you're drinking could be your last.

The mystery behind hummingbirds' ability to taste sugar starts, as Science 2.0 explains, with chickens:

> Before scientists sequenced its genes, people assumed that chickens and all birds taste things the same way that mammals do: with sensory receptors for salty, sour, bitter, sweet and the more recently recognized umami taste, which comes from the Japanese word for savory.
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> The canonical view stated there was a sweet receptor present in animals, much smaller than the large families of receptors involved in smell and bitter taste perception—vital for sensing safe food or dangerous predators.

But chickens refused to comply with the canonical view: their genome had no trace of a sweet-taste receptor gene. This made Harvard PhD student Maude Baldwin curious, according to Science 2.0:

> "The immediate question to ornithologists or to anybody who has a birdfeeder in the backyard was: What about hummingbirds?" she recalled. "If they are missing the single sweet receptor, how are they detecting sugar?"

In a paper published in Science, Baldwin and her lab-mates have an answer: the umami receptor has been transformed, at a molecular level, to respond to sugars instead of umami flavors. The Christian Science Monitor breaks down their experimental procedure:

> To figure out what made hummingbirds like sweets despite their lack of the sweet-taste receptor, Baldwin and colleagues cloned the genes for the T1R1-T1R3 taste receptors from omnivorous chickens, insectivorous swifts and nectivorous hummingbirds. The researchers

> then tested how the taste-receptor proteins produced by these genes reacted to different "flavors" in a cell culture.
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> For chickens and swifts, the receptor had a strong reaction to the amino acids behind umami flavors. The hummingbird receptor, on the other hand, was only weakly stimulated by umami flavors, but it did responded strongly to the sweet flavors of carbs, the researchers found.
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> Then, to look for the molecular basis for this change in function, Baldwin and colleagues made taste-receptor hybrids using different parts of the chicken and hummingbird receptors. They found that by mutating the chicken receptor in 19 different places, they could get it to respond to sweets, but the researchers suspect there are more mutations that contributed to the change in hummingbirds.

This discovery of how hummingbirds are able to discern the sugar they depend on without the usual taste receptors opens up the floor to questions about other birds with a "sweet tooth," like fruit-eating orioles or nectar-drinking honeycreepers. Some context from New Scientist:

> "We know a lot about bird vision and smell, but until recently very little was known about the genetic basis of taste in any bird species," says Hannah Rowland at the University of Cambridge, who was not involved in the study. "These findings should help researchers test sweet perception in other birds that eat fruit and nectar. The question for me is whether other nectar eating birds and frugivores have evolved this same capacity."
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> The re-evolution of sugar receptors may have happened multiple times, says study member Stephen Liberles, also at Harvard. "It will be exciting to see how other nectar feeding birds taste sugar, to compare whether evolution used the same or different strategies to solve the problem of sugar detection," he says.

Most interesting, perhaps, is the potential link to dinosaurs. Modern carnivores tend to have a stunted taste for sweetness. And "birds are the descendants of carnivorous dinosaurs, so maybe this gene [for sweet-taste receptors] was lost early on because of the diet of their ancestors," Baldwin told the Christian Science Monitor.

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Additional Resources:

- Researchers Discover Biological Mechanism Behind The Hummingbird's Sweet Tooth, redOrbit
- The Tree of Smells, The Loom (National Geographic blog)
- Vampire Bats' Blood Diet Numbed Their Taste Buds, Discover