Science Sushi

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Evolution: Watching Speciation Occur | Observations

- By Christie Wilcox on December 18, 2011

This is a repost from April 24th, 2010. Watching Speciation Occur is the second in my Evolution series which started with The Curious Case of Dogs

We saw that the littlest differences can lead to dramatic variations when we looked at the wide variety in dogs. But despite their differences, all breeds of dogs are still the same species as each other and their ancestor. How do species split? What causes speciation? And what evidence do we have that speciation has ever occurred?

Critics of evolution often fall back on the maxim that no one has ever seen one species split into two. While that's clearly a straw man, because most speciation takes far longer than our lifespan to occur, it's also not true. We *have* seen species split, and we continue to see species diverging every day.

For example, there were the two new species of American goatsbeards (or salsifies, genus *Tragopogon*) that sprung into existence in the past century. In the early 1900s, three species of these wildflowers - the western salsify (*T. dubius*), the meadow salsify (*T. pratensis*), and the oyster plant (*T. porrifolius*) - were introduced to the United States from Europe. As their populations expanded, the species interacted, often producing sterile hybrids. But by the 1950s, scientists realized that there were two new variations of goatsbeard growing. While they looked like hybrids, they weren't sterile. They were perfectly capable of reproducing with their own kind but not with any of the original three species - the classic definition of a new species.

How did this happen? It turns out that the parental plants made mistakes when they created their gametes (analogous to our sperm and eggs). Instead of making gametes with only one copy of each chromosome, they created ones with two or more, a state called polyploidy. Two polyploid gametes from different species, each with double the genetic information they were supposed to have, fused, and created a tetraploid:

an creature with 4 sets of chromosomes. Because of the difference in chromosome number, the tetrapoid couldn't mate with either of its parent species, but it wasn't prevented from reproducing with fellow accidents.
This process, known as Hybrid Speciation, has been documented a number of times in different plants. But plants aren't the only ones speciating through hybridization: *Heliconius* butterflies, too, have split in a similar way.

It doesn't take a mass of mutations accumulating over generations to create a different species - all it takes is some event that reproductively isolates one group of individuals from another. This can happen very rapidly, in cases like these of polyploidy. A single mutation can be enough. Or it can happen at a much, much slower pace. This is the speciation that evolution is known for - the gradual changes over time that separate species.

But just because we can't see all speciation events from start to finish doesn't mean we can't *see* species splitting. If the theory of evolution is true, we would expect to find species in various stages of separation all over the globe. There would be ones that have just begun to split, showing reproductive isolation, and those that might still look like one species but haven't interbred for thousands of years. Indeed, that is exactly what we find.

The apple maggot fly, *Rhagoletis pomonella* is a prime example of a species just beginning to diverge. These flies are native to the United States, and up until the discovery of the Americas by Europeans, fed solely on hawthorns. But with the arrival of new people came a new potential food source to its habitat: apples. At first, the flies ignored the tasty treats. But over time, some flies realized they could eat the apples, too, and began switching trees. While alone this doesn't explain why the flies would speciate, a curious quirk of their biology does: apple maggot flies mate on the tree they're born on. As a few flies jumped trees, they cut themselves off from the rest of their species, even though they were but a few feet away. When geneticists took a closer look in the late 20th century, they found that the two types - those that feed on apples and those that feed on hawthorns - have different allele frequencies. Indeed, right under our noses, *Rhagoletis pomonella* began the long journey of speciation.

As we would expect, other animals are much further along in the process - although we don't always realize it until we look at their genes.
Orcas (*Orcinus orca*), better known as killer whales, all look fairly similar. They're big dolphins with black and white patches that hunt in packs and perform neat tricks at Sea World. But for several decades now, marine mammalogists have thought that there was more to the story. Behavioral studies have revealed that different groups of orcas have different behavioral traits. They feed on different animals, act differently, and even talk differently. But without a way to follow the whales underwater to see who they mate with, the scientists couldn't be sure if the different whale cultures were simply quirks passed on from generation to generation or a hint at much more.

Now, geneticists have done what the behavioral researchers could not. They looked at how the whales breed. When they looked at the entire mitochondrial genome from

139 different whales throughout the globe, they found dramatic differences. These data suggested there are indeed at least three different species of killer whale. Phylogenetic analysis indicated that the different species of orca have been separated for 150,000 to 700,000 years.

Why did the orcas split? The truth is, we don't know. Perhaps it was a side effect of modifications for hunting different prey sources, or perhaps there was some kind of physical barrier between populations that has since disappeared. All we know is that while we were busy painting cave walls, something caused groups of orcas to split, creating multiple species.

There are many different reasons why species diverge. The easiest, and most obvious, is some kind of physical barrier - a phenomenon called Allopatric Speciation. If you look at fish species in the Gulf of Mexico and off the coast of California, you'll find there are a lot of similarities between them. Indeed, some of the species look almost identical. Scientists have looked at their genes, and species on either side of that thin land bridge are more closely related to each other than they are to other species, even ones in their area. What happened is that a long time ago, the continents of North and South America were separated, and the oceans were connected. When the two land masses merged, populations of species were isolated on either side. Over time, these fish have diverged enough to be separate species.

Species can split without such clear boundaries, too. When species diverge like the apple maggot flies - without a complete, physical barrier - it's called Sympatric Speciation. Sympatric speciation can occur for all kinds of reasons. All it takes is something that makes one group have less sex with another.
For one species of Monarch flycatchers (*Monarcha castaneiventris*), it was all about looks. These little insectivores live on Solomon Islands, east of Papua New Guinea. At some point, a small group of them developed a single amino acid mutation in the gene for a protein called melanin, which dictates the bird's color pattern. Some flycatchers are all black, while others have chestnut colored bellies. Even though the two groups are perfectly capable of producing viable offspring, they don't mix in the wild. Researchers found that the birds already see the other group as a different species. The males, which are fiercely territorial, don't react when a differently colored male enters their turf. Like the apple maggot flies, the flycatchers are no longer interbreeding, and have thus taken the first step towards becoming two different species.

These might seem like little changes, but remember, as we learned with dogs, little changes can add up. Because they're not interbreeding, these different groups will accumulate even more differences over time. As they do, they will start to look less and less alike. The resultant animals will be like the species we clearly see today. Perhaps some will adapt to a lifestyle entirely different from their sister species - the orcas, for example, may diverge dramatically as small changes allow them to be better suited to their unique prey types. Others may stay fairly similar, even hard to tell apart, like various species of squirrels are today.

The point is that all kinds of creatures, from the smallest insects to the largest mammals, are undergoing speciation right now. We have watched species split, and we continue to see them diverge. Speciation is occurring all around us. Evolution didn't just happen in the past; it's happening right now, and will continue on long after we stop looking for it.

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Image Credits:
Salsify plate showing two new species from the New Zealand Plant Radiation Network (taken from Ownbey, 1950 in which the species were described)
Flycatchers image by Robert Boyle, as featured on Science Now

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