

Powdery mildew at an evolutionary dead end

9 December 2010



The photograph shows a section of a powdery mildew-infected barley leaf. The whitish fungal colonies on the leaf surface represent the typical disease symptoms of this widespread plant disease. Credit: Anja Reinstädler (MPI für Pflanzenzüchtungsforschung)

The size of a genome tells us nothing about the comprehensiveness of the genetic information it contains. The genome of powdery mildew, which can destroy entire harvests with its fine fungal threads, is a good example of this. Although the pathogen has almost 120 million base pairs, and therefore one of the largest genomes of the sac fungi, at barely 6,000, its gene count is far lower than that of comparable species.

It has lost many of the [genes](#) required for separate metabolism found in other fungi. Thus, from a genetic perspective, [powdery mildew](#) is stuck in an evolutionary dead end from which it is unable to liberate itself. (*Science*, December 10, 2010)

Based on the comparison of fungal genomes, Ralph Panstruga from the Max Planck Institute for [Plant Breeding](#) Research in Cologne and his colleagues from an international research consortium discovered that powdery mildew forfeited a large part of its genetic complexity in the course of evolution. The considerable size of the mildew genome is largely due to so-called "jumping genes". These genes introduce new sequences into the genome and repeatedly mix up the genetic material by inserting and deleting

themselves, causing errors as a result. Due to these changes, the powdery mildew [fungus](#) gained a considerable number of new base pairs, but it also lost a lot of genes as their reading frames were interrupted by the insertion of the jumping genes.

As the international consortium of scientists succeeded in demonstrating, the plant pathogen lacks 99 genes that enable independent life, yet are still found in baker's yeast, another sac fungus. Therefore, powdery mildew cannot fix nitrogen, harness energy from alcoholic fermentation or produce certain metabolic products from inorganic compounds. As a parasite, powdery mildew does not require these synthesis processes; it obtains everything it needs from the host plant. Panstruga explains: "It can do without these genes. However, the price it pays is being forced to adhere to a particular way of life: parasitism. It has no way back to independent life. This is precisely what Dollo's Law states: once lost, the very same genetic complexity can never be regained. That's why extinct species cannot be re-established from the available genomes."

Powdery mildew also lacks many of the genes necessary for attacking the plant cell. For example, it only produces a few transport proteins; other plant diseases produce an entire collection of these proteins. They use these to infiltrate toxins into the plant cell or to pump the plant's immune defence proteins out of the cell so that they no longer pose a threat. Powdery mildew also forms very few enzymes that can be used to perforate the wall of the plant cell and thereby gain entry to it. "The powdery mildew fungus obviously lacks the genetic equipment to launch a broad attack on the plant cell. Instead, its strategy is to slip into the plant unobtrusively. It tries not to give the plant immune system any opportunity for a defensive reaction. This also suits its parasitic way of life. Powdery mildew is not interested in the destruction of the host plant. What it wants is the subtle and enduring subjugation of its host", says Panstruga.

The mildew pathogen colonizing barley uses just four percent of its genetic armoury for this subjugation. The Cologne-based scientists only identified 248 genes that could possibly be used for such a task. The comparison with other mildew species - for example pea or Arabidopsis mildew - revealed that the three species share only seven of these genes. All of the others are found only in the barley mildew. This exclusivity shows that its genetic equipment developed with a view to establishing a parasitic existence in close association with the relevant host plant. The other mildew species have clearly found other genetic solutions.

More information: Spanu PD et al. Genome expansion and gene loss in powdery mildew fungi reveal functional tradeoffs in extreme parasitism, *Science*, December 10, 2010

Provided by Max-Planck-Gesellschaft

APA citation: Powdery mildew at an evolutionary dead end (2010, December 9) retrieved 24 November 2020 from <https://phys.org/news/2010-12-powdery-mildew-evolutionary-dead.html>

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