Frogs reveal mechanism that determines viability of hybrids

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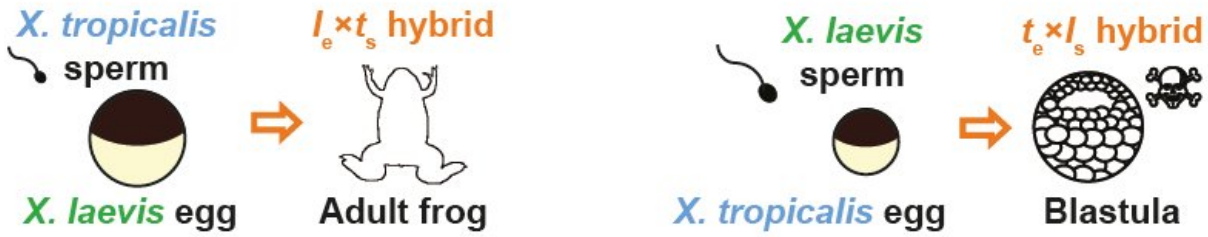

Crossbreeding *Xenopus laevis*, the African clawed frog, and *Xenopus tropicalis*, the Western clawed frog has asymmetric results. When a female African clawed frog is crossbred with a male Western clawed frog, the embryos are viable. However, the other way around, crossbreeding a male African clawed frog and a female Western clawed frog leads to embryos that die in the early stages of development. Researchers found the reason for this: the maternal molecular machinery of the Western clawed frog cannot fully recognize the paternal chromosomes of the African clawed frog. The separation of the paternal chromosomes during cell division is disrupted. As a consequence, the cells lack a large number of vital genes and quickly die. Credit: University of California Berkeley, Radboud University

Why are some hybrids viable and others not? It is known that this depends on the father species and the mother species. New research in two related frog species shows the influence of mother and father species: One hybrid is viable, the other hybrid dies in early stages of development. Scientists from Radboud University, together with

colleagues from the United States and Japan, published their findings on 10 January in *Nature*.

When two related species crossbreed, their genetic material crosses, which can lead to new species. But every so often, there is a difference in the offspring, depending on which of the two species is the mother and which one is the father. A well-known example of a hybrid is a mule, the offspring of a male donkey and a female horse. The other way around, the offspring of a female donkey and a male horse is a different animal—a hinny. It thus makes a difference which species is the father and which one is the mother.

One hybrid is viable, the other hybrid is not

Both mules and hinnies are infertile, because donkeys and horses have a different number of chromosomes, the protein structures on which genetic material is present. Yeasts, plants, fish and amphibians (in contrast to mammals) can, however, produce fertile hybrids. Professor of Molecular Developmental Biology Gert Jan Veenstra says, "For instance, in frogs a duplication of chromosomes can appear, in which the whole set of chromosomes from the father and the mother are passed on to the next generation."

However, there is another problem: Some hybrids are not viable, while crossbreeding the other way around is. The embryos are genetically identical, but there is a difference in viability, depending on the father species and the mother species. Veenstra says, "Even though it is vital for evolution, the mechanisms of viable and non-viable hybrids are to this date unknown."

Crossbreeding the African and Western clawed frog

The scientists showed this phenomenon in research with two related frog species: Xenopus tropicalis and Xenopus laevis (also known as the Western and African clawed frogs, respectively). When a female African clawed frog is crossbred with a male Western clawed frog, the embryos are viable. However, the other way around, crossbreeding a male African clawed frog and a female Western clawed frog leads to embryos that die in the early stages of development. Why that is, remained unclear.

The researchers report what went wrong during this crossbreeding: The maternal molecular machinery of the Western clawed frog cannot fully recognize the paternal chromosomes of the African clawed frog. Two specific pieces of the paternal chromosomes are incompatible with the maternal cell, and thus the separation of the chromosomes during cell division is disrupted. These cells now lack a large number of important genes, such as genes for metabolism, and therefore quickly die.

This shows there is a strong asymmetry when it comes to hybrids, depending on the father species and mother species. "These findings are important, because this type of hybrid is present in nature and in some cases leads to new species. When new species emerge, there seems to be a period of transition: Closely related species are able to produce viable offspring, but if the chromosomes are no longer compatible it leads to asymmetric results of crossbreeding. When species further separate, crossbreeding no longer leads to viable offspring. We here show the cellular mechanism behind this phenomenon," says Gert Jan Veenstra.

The viable hybrid of a male Western clawed frog and a female African clawed frog also revealed a molecular mechanism: parasitic DNA elements (transposons) are activated in one of the genomes. Veenstra says, "The female's immune system is not wired to recognize the paternal transposons and hence does not repress them. As a consequence, parasitic DNA elements are now able to fulfill a new role: they can act as

regulatory DNA that influences gene activity. This may have a large influence on formation and characteristics of a new species." These findings were published in *Genome Biology* (Elurbe et al, 2017).

More information: Romain Gibeaux et al, Paternal chromosome loss and metabolic crisis contribute to hybrid inviability in Xenopus, *Nature* (2018). DOI: 10.1038/nature25188