

# Can Genetic Mutations be Purged from the Genome?

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How mutations could be removed from a genome through inbreeding, though the original integrity could not be restored in reality or in an evolutionary paradigm.

## Abstract

Mutations are an ongoing problem in nature. Since the vast majority of mutations are deleterious, even by admission of the evolutionary community (Lande 1994), in theory, genomes should always be breaking down. The result of this breakdown should be a reduction in fitness, leading to extinction. And if this were true, extinction for all species would be inevitable in short order. Thus, to avoid the logical consequences of mutations destroying genomes over vast periods of time, evolutionists must theorize a way for these deleterious mutations to be eliminated from the genomes of living things. There have been several proposed mechanisms to do this for different contexts, but here we will focus on just one: purging by purifying selection.

In order to understand and assess the possibility of purging, it is important to understand the context. For purging, the context is inbreeding. Theoretically, in a population of infinite size, inbreeding (mating between close relatives) is not likely to occur. However, no population is that large. Many species have populations that number in the hundreds to low thousands, and discrete population sizes may be even smaller. Therefore, inbreeding is a common problem, particularly among endangered species.

## To Breed or Not to Breed

Inbreeding can be slowed by a preference for mating non-relatives. In some species, like mice, the basis for inbreeding avoidance is genetic (expressed through scent) (Sherborne et al. 2007). In other species, like *Parus major* birds, the avoidance is based on dispersal from where they are born (Szulkin and Sheldon 2008). In African elephants, behavioral choices are the reason inbreeding does not occur (Archie et al. 2007). Other reasons might be possible as well. What this means is that there are multiple ways different species discourage inbreeding.

However, many species do not avoid inbreeding. For example, the dwarf mongoose makes little effort to avoid inbreeding. Neither young males nor females leave the pack regularly when they are related to the dominant member of the opposite sex (Keane, Creel, and Waser 1996). A full 59% of song sparrow matings were between known relatives (Keller and Arcese 1998). Mating is completely random in great reed warblers (Hansson et al. 2007). And worse, even when deliberate outbreeding is employed, one result of inbreeding, inbreeding depression, still happens (Larsen et al. 2011).

Inbreeding depression is the loss of fitness as defined by “the reduced survival and fertility of offspring of related individuals.”

Inbreeding depression is the loss of fitness as defined by “the reduced survival and fertility of offspring of related individuals” (Charlesworth and Willis 2009). and is caused by the accumulation of deleterious mutations (Charlesworth and Charlesworth 1999). It is important to point out that inbreeding depression is relative. The reduction in survival and fertility is in relation to either a previous population standard or a different population that is not suffering inbreeding (Charlesworth and Charlesworth 1999). What this means is that the loss of fitness may be worse than realized. Since inbreeding depression is compared to a population standard, and that population standard is declining too, inbreeding depression will likely be under-measured.

## To the Rescue?

With inbreeding depression having the potential to cripple or destroy a population within just a few generations (Liberg et al. 2005), the consequences could be catastrophic if it is not removed. *Purging* is a controversial explanation to some extent within the scientific community, with some papers showing no evidence for it, even in the presence of severe inbreeding depression (Kennedy et al. 2013). A meta-analysis of 28 studies found that the ways to measure purging did not give concordant results, suggesting that some measurements of purging are inaccurate (Crnokrak and Barrett 2002).

Purging is accomplished by intensified inbreeding. Essentially, inbreeding creates homozygous organisms for deleterious alleles.

Purging is accomplished by intensified inbreeding. Essentially, inbreeding creates homozygous organisms for deleterious alleles. This exposes the recessive deleterious alleles to selection, allowing them to be removed. But not all alleles are equally deleterious, and selection will act against the worst ones first. When these alleles are lethal, purging can happen quickly (Hedrick 1994).

Most deleterious alleles are not lethal. In such cases, the worst alleles are purged, but the less deleterious alleles are not. In a recent study in rattlesnake species, an endangered species had less highly deleterious mutations in both homozygotes and heterozygotes than a closely related species that is not endangered (Ochoa and Gibbs 2021). However, the endangered species had more homozygotes for every other type of deleterious allele. So, the endangered species was more likely to express every type of deleterious allele except the worst type, and the deleterious mutations in the endangered species were doing more damage than the ones in the non-endangered species.

This pattern also appears in a restored population of Alpine ibex. The population was reduced to roughly 100 individuals as recently as the 1800s but now is close to 50,000. The very stringent bottleneck may have purged the most deleterious alleles, but the less deleterious alleles are still present and continue to accumulate (Grossen et al. 2020). Purging apparently cannot stop the accumulation of deleterious alleles; it can only remove the worst.

Other studies, such as a study on captive ungulate species, found similar results. Using historic pedigrees, they were able to calculate exactly how inbred each individual was and predict how long purging would take. Purging occurred in two species, but it only purged “a substantial fraction of their inbreeding load and inbreeding depression” (López-Cortegano, Moreno, and García-Dorado 2021). In other words, not all the deleterious alleles were purged.

Because population bottlenecks create the conditions necessary for purging, it has been suggested in conservationist literature that deliberate inbreeding could be used to purge captive populations of endangered organisms (Templeton and Read 1984), or at least provide beneficial conservation results (Moreno et al. 2015). However, it is not quite so simplistic. Inbreeding depression has been shown to become more severe under worse environmental conditions (Bijlsma, Bundgaard, and van Putten 1999). That means that, while deliberate inbreeding to purge a population may work in theory, the increased inbreeding prior to the purge would likely harm a wild population.

Laboratory results send a similar message. In mosquitofish, neither single nor multiple bottlenecks resulted in purging (Leberg and Firmin 2008). However, multiple bottlenecks had significant negative effects. Populations founded by close relatives produced less fry and, when experiencing multiple bottlenecks, were significantly less likely to successfully start a new population (Larsen et al. 2011). In an experiment on guppies, ten generations of inbreeding were enough for five of the inbred populations to go extinct (Fox, Scheibly, and Reed 2008). In an experiment on beetles, inbreeding did even more damage, sending 60–63% of inbred lineages extinct inside four generations! Purging by increasing inbreeding might work, but it comes at a steep risk of extinction.

Purging of inbreeding depression might work in some limited cases. However, it does not remove all the deleterious mutations from the genome.

## Conclusion

Purging of inbreeding depression might work in some limited cases. However, it does not remove all the deleterious mutations from the genome. Instead, just like other forms of selection, it removes the worst. What this means is that the perfect genomes created in the beginning continue to break down. Purging does not provide the mechanism evolution needs to restore genomic degradation. It might restore fitness for a short period of time, but it cannot restore genetic integrity.

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