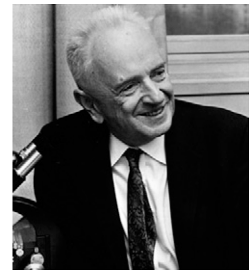
Theodosius Dobzhansky on Hybrid Sterility and Speciation



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ORIGINAL CITATION
Studies on Hybrid Sterility. II. Localization of Sterility Factors in *Drosophila pseudoobscura* Hybrids
Theodosius Dobzhansky
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It is a truth universally acknowledged that *Genetics and the Origin of Species*, Theodosius Dobzhansky's acclaimed 1937 book, launched the modern evolutionary synthesis, characterized by uniting the findings of genetics with the facts of natural history. Dobzhansky's title deliberately contained Darwin's, as the book discussed a problem broached but not solved by *On the Origin of Species* (Darwin 1859): the evolution of biodiversity. Despite Darwin's title, his book dealt mainly with genetic change *within* a species, not the origin of new species themselves. Thus, in his first two pages Dobzhansky argued that the major outstanding problem of evolutionary biology was "the discontinuity of the organic variation," *i.e.*, the existence of discrete clumps of organisms—those entities we call species.

Recognizing that explaining the existence of species was identical to explaining the origin of "isolating mechanisms" that prevent gene flow, one of Dobzhansky's goals in the 1937 book was to unite microevolution and macroevolution—to explain how selection acting on populations of a species could eventually transform them into distinct species.

Dobzhansky's (1936) article in *GENETICS* represents the first concerted effort to work out the genetic changes producing a puzzling reproductive barrier: hybrid sterility. How, wondered Dobzhansky, could such a phenomenon possibly arise via natural selection, given that such selection produces sterile offspring? The answer involved what has become known as the "Dobzhansky–Muller" hypothesis: the notion that geographically isolated populations could evolve allelic changes at *different* gene loci, so that the sterility, which appears only after divergently evolved groups encounter each other, would never occur within a population (Orr 1995). Such intergenic interactions ("Dobzhansky–Muller incompatibilities" [DMIs]) are in fact now widely accepted as the origin of nearly all intrinsic postzygotic reproductive isolation, including hybrid sterility and inviability. Dobzhansky's article provided the first evidence that led to this acceptance (*cf*. Orr 1996).

Dobzhansky tested his hypothesis by crossing two species (then known as "race A and race B" of *Drosophila pseudoobscura*, now recognized as *D. pseudoobscura* and *D. persimilis*, respectively) and then backcrossing the hybrid females (males are sterile) to males from both pure species. This produces a variety of backcross males having combinations of genes from the two species. To identify the species origin of chromosomes and arms, Dobzhansky used a combination of dominant and recessive genetic markers that would show a hybrid's genetic constitution by the mutants it displayed. Each male's testis size was then measured as an index of fertility.

Despite the imperfection of this index (some hybrid males have normal-sized testes but no sperm) and the lack of statistical analysis, Dobzhansky's results were clear: hybrid male sterility involved at least seven genes on all four major chromosomes, with the largest effect on fertility involving interactions between the X chromosome of one species and the autosomes of the other. This was a direct confirmation of the role of DMIs in hybrid sterility.

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After this article appeared, however, studies of the genetics of speciation lay fallow for nearly half a century (Coyne 1985). Eventually, geneticists realized that, with the advent of molecular markers, one could do much more thorough studies of the genetics of isolating barriers and even isolate some of the genes involved in postzygotic interactions. The studies of these two species were repeated using both morphological and molecular markers, bringing the total number of genes causing sterility up to 10 and confirming Dobzhansky's finding of the importance of X–autosome interactions (Orr 1987; Noor *et al.* 2001).

Similar interactions were soon discovered in many other species, so that the twin phenomena of heterogametic hybrid sterility ("Haldane's rule") and the exaggerated effect of the X chromosome became virtual "laws of speciation," demanding explanation (Coyne and Orr 1989). We now know that both phenomena are due to several factors: the recessivity of genes causing postzygotic isolation, their preferential accumulation on the X chromosome (perhaps due to its faster evolution), and the possibility of X-linked meiotic drive that produces hybrid sterility as a by-product (Orr 1993; Wu and Davis 1993; Turelli and Orr 2000; Tao and Hartl 2003; Presgraves 2008; McDermott and Noor 2010; Meisel and Connallon 2013). These remain active areas of research, as does work on identifying the precise genes causing postzygotic isolation and the forces driving their evolution.

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