GERMLINE IMMORTALITY

Every generation is born biologically young, even when parents are old.
A new essay in PLOS Biology by Chiavellini and Sebastiano (1) argues that the answer lies in the oocyte.

Despite residing in an aging ovary within an aging organism, the egg executes a remarkable molecular reset before passing the genome to the next generation. Global epigenetic reprogramming erases age-associated drift accumulated over a lifetime; a mitochondrial bottleneck selectively amplifies high-functioning organelles and filters out dysfunctional ones; autophagy clears damaged proteins at the moment of fertilization. No other adult cell type routinely performs this coordinated renewal. The authors call it a blueprint for rejuvenation, and draw a direct parallel to experimental approaches such as partial reprogramming, which attempt to recreate in somatic tissues what the oocyte does naturally.

The reset operates across three layers simultaneously: the epigenome, the organelles, and the proteome. It is also tightly regulated, not haphazard. Certain genomic regions resist complete demethylation, preserving stability. The ovarian niche itself contributes, selecting through atresia the most competent oocytes for reproduction. And crucially, the oocyte does not act alone: the cytoplasmic machinery that reprograms both parental genomes after fertilization is entirely of maternal origin, including the elimination of paternal mitochondria. The egg is not just a vehicle for DNA, it is the engine of biological renewal.

But this reset has a fundamental limit. The oocyte resets the epigenome, the mitochondria, the proteome. It does not rewrite the DNA sequence itself. Genomic mutations accumulate in the parental germline and are faithfully transmitted to the offspring. As discussed in an earleir post, serial cloning experiments showed exactly this: oocyte-mediated reprogramming occurred at every generation, yet underlying DNA mutations continued to accumulate until the lineage collapsed at generation 58 (2).

This is where sexual reproduction acts as the complementary mechanism. Meiosis and recombination reshuffle variation; selection then acts on the result. As shown experimentally in Tribolium flour beetles, populations with strong sexual selection — male competition, female choice — purge deleterious variants far more effectively than those reproducing without it (3). The oocyte resets what each generation inherits at the molecular level; sexual selection filters the DNA sequence itself across generations. Together, they explain what the germline actually is: an unbroken chain of living cells that reaches back, without a single interruption, to the origin of life 3.5 billion years ago.

1. https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3003804
2. https://www.nature.com/articles/s41467-026-69765-7
3. https://www.nature.com/articles/nature14419