THE EQUILIBRIUM OF THE MUTATION RATE

Every organism needs mutations to evolve. Too many mutations would be catastrophic. But too few would be just as bad - perhaps worse. Without a steady supply of new variants, populations would indeed lose the raw material needed to adapt to changing environments. The mutation rate is therefore not a flaw in the system. It is the system.

Porubsky et al. (1) have calculated, thanks to long-read sequencing, that every time a human being has a child, the newborn's genome carries an average of about 75 new point mutations, contributed roughly equally by each parent.

De Manuel and colleagues (2) looked for the mutation rate beyond humans. Measuring germline mutation rates across dozens of animal species, from nematodes with generation times of just three days, to whales that reproduce every two decades, they found that the rate per base pair per generation barely changes: it stays within roughly one order of magnitude (~10^{-9} to 10^{-8}) across the entire animal kingdom. A mouse passes along fewer absolute mutations per generation than a human, but the per-bp rate is comparable. So does a fruit fly, a stickleback, a chimpanzee.
Three orders of magnitude in generation time and one order of magnitude in mutation rate is not a coincidence. It is a signature of natural selection actively maintaining an equilibrium. Species that drift too far above it, pay a fitness cost in deleterious mutations; those that drift too far below it, lose evolutionary flexibility. The result, across radically different life histories and environments, converges on roughly the same solution.

Understanding how selection enforces this balance, through the interplay of DNA repair fidelity, damage tolerance, and population size, is now one of the central questions in evolutionary biology. But the fact that such a balance exists, and that it is shared so broadly across the tree of life, is itself a remarkable discovery.

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