The evolution of complexity

Mendel's Demon: Gene Justice and the Complexity of Life

By Mark Ridley

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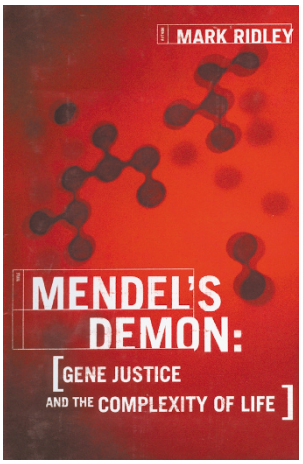
Mendelian inheritance is a magnificent innovation. It is like a factorial experiment in which each factor occurs in combination with all others and is therefore fairly assessed on its own merits. Meiosis achieves this by randomization such that each gene has an equal probability of being included in a gamete.



Mark Ridley (easily confused with another skilled writer, Matt Ridley) has entitled his book *Mendel's Demon*. This comes from 'Maxwell's Demon,' James Clerk Maxwell's little guy who sits at a small hole between two containers and lets the faster gas particles through one way and slower ones, the other. In so doing, he permits one container to get hotter and the other, colder, and so violates the second law of thermodynamics. In contrast, Mendel's Demon randomizes. To work properly, Mendelian inheritance demands that the process be scrupulously fair. Mendel's Demon ensures this.

This book covers the whole history of life. It cuts a wide swath. It is generally accurate, but sometimes oversimplified—reasonably in my view. Ridley argues that life, rather than being a most unlikely, freakish accident, is highly probable, given the chemistry of the prebiotic earth. Part of his evidence is the short interval between the origin of the earth and the appearance of life. In contrast, there was a very long gap—some 2–3 billion years—before complex organisms appeared. Life is probable, complex life improbable. If there is life elsewhere, or if our own tape had been rerun, complexity may well not have arisen.

The essence of life is the capacity to evolve by natural selection. In successive chapters, Ridley discusses the role of selection in the evolution of gene number, mutational meltdown, and adjustment of mutation rates. Surprisingly, there has not been much change in the frequency of mutational errors since the origins of multicellularity. A major change in complexity was evolution of the eukaryotic cell, containing seperate nuclear, mitochondrial, and plastid systems. The big step from prokaryotes to eukaryotes arose from the fusion of two prokaryotes, the "one big merger event in the history of complexity."

Then comes a long discussion of sexual reproduction, "the ultimate existential absurdity." Why is sex so ubiquitous despite a twofold reduction of fitness ? Ridley discusses two possibilities. One is that it provides a way to keep up with a changing environment, especially parasites. His main emphasis, however, is on how synergistic epistasis, which he calls "escalating damage," can reduce the probability of mutational meltdown, extinction through accumulation of harmful mutations. Ridley notes that a human zygote has some 200 new mutations, and believes that 2–20 are harmful. He is much taken by Alex Kondrashov's arguments (as am I) that truncation selection can provide an effective mutation-eliminating mechanism. (Truncation selection eliminates all individuals with more than a threshold number of mutations.) But, as strict truncation selection seems unlikely, I wish the author had brought out that a very loose approximation to truncation works nearly as well. Also, I would like to know what he thinks of bdelloid rotifers, which have survived asexuality long enough to create an 'evolutionary scandal.'

There is an arresting treatment of transmission distortion, with the *Segregation Distorter* locus in *Drosophila* as a model. Here, Ridley has employed the clever metaphors of "assassin genes," "target genes" and "safe-conduct genes." He shows how independent assortment protects against the ravages of assassins—genes that 'liquidate' homologous target genes. In his words: "Mendel's second law, the law of gene shuffling, evolutionarily acts to enforce the first law, the law of fair heredity, and where gene shuffling is prevented gene justice breaks down." He even invokes Machiavelli's ideas for avoiding conspiracies, with recombination the means of suppressing the genetic versions. "Without it," he says, referring to recombination, "we should not exist."

Two chapters are devoted to various kinds of conflicts: between nucleus and mitochondrion, between the sexes, between egg and sperm, between embryo and mother. He views imprinting as a consequence of the latter conflict. These chapters are strongly influenced by the imaginative work of David Haig. Among other ideas, Haig gives a plausible reason for meiosis being a two-division process rather then a simpler single division. In discussing a female's choice of males, Ridley argues that healthy males reveal their superior health by various appearances and displays. I would like to know what clever analogies he would use to describe R.A. Fisher's runaway process in which females, by choosing the most spectacular males, assure somewhat spectacular sons and thus help to perpetuate the 'spectacular' genes, as well as genes leading females to prefer such males.

Ridley then deals specifically with the human situation. The main questions are two: First, whether our seemingly exorbitant mutation rate brings us anywhere near to a mutational meltdown. Next, whether relaxed selection has a large effect on mutation accumulation. Again, he is impressed by truncation selection, but he also points out that selection can work on all phases of the life cycle, especially on early embryonic stages, which are usually unobserved.

The last part of the book is an enigma. It is part genetics, part evolution, part biblical metaphor, part science fiction—and all speculation (as the author warns). There are interesting ideas, but my advice is: don't inhale. My guess is that technology is changing so rapidly that even the most carefully reasoned future scenarios will soon be irrelevant. Yet they're enjoyable and stimulating.

Ridley is especially good at inventing analogies from familiar things—books, machines, language, manuscript copiers. They are the sugar coating on a sometimes difficult biological pill, driving home the message without getting the reader bogged down in troublesome details. And yet, there may be the danger of savoring the sugar while missing the pill. The instructor in my college physics course once produced a spectacular contrivance of mouse and rat traps to illustrate how a vacuum tube works. Alas, I remember the snapping traps, but I don't remember the first thing about vacuum tubes. □