

# A Simple Model of the Evolution of Simple Models of Evolution

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## Abstract

In the spirit of the many recent simple models of evolution inspired by statistical physics, we put forward a simple model of the evolution of such models. Like its objects of study, it is (one supposes) in principle testable and capable of making predictions, and gives qualitative insights into a hitherto mysterious process.

Even the most casual perusal of *Physical Review Letters*, *Physical Review E*, *Journal of Statistical Physics* or the Los Alamos e-print archive for nonlinear systems could not fail to reveal that the last decade, indeed, the last few years, have seen a remarkable explosion of simple models of biological evolution formulated by physicists. These draw their inspiration not from the founding works on the mathematical modeling of evolutionary processes (Fisher (1958), Haldane (1932) and Wright (1986)), nor from the extensive development and refinement of this theory by six subsequent decades of active research (*e.g.*, Hamilton (1996), Maynard Smith (1982, 1989), Hofbauer and Sigmund (1988)), nor the highly abstract Holland (1992), nor even the less orthodox biologists (*e.g.*, Kauffman (1993)) but from models well-established in statistical physics — sandpiles, reaction-diffusion systems, phase transitions, &c., &c. Cynics have said that mathematical physics is that which hasn't enough rigor and generality

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to be math, but not enough contact with reality to be physics; fortunately we are not cynics, or we would not be able to resist making the analogous *bon mot* about this new wave of physico-biology (Lotka, 1924).

The question presents itself: why are we being deluged with such models? In the spirit of the field, we present a simple evolutionary model of this process.

1. A physicist runs across or concocts from whole cloth a mathematical model which is simple, neat, and contains a great many variables of the same sort.
2. The physicist has heard of Darwin (1859), and may even have read Dawkins (1985) or some essays by Gould, but wouldn't know Fisher (1958), Haldane (1932) and Wright (1986) from the Three Magi, and doesn't dream that such a subject as mathematical evolutionary biology exists.
3. The physicist is aware that lots of other physicists are interested in annexing biology as a province of statistical physics.
4. The physicist interprets his multitude of variables as species or (if slightly more sophisticated) as *genotypes*, and proclaims that he has found "Darwin's Equations" (*cf.* Bak *et al.* (1994)), or, more modestly, has made an important step towards eventually finding those equations.
5. His paper is submitted for review to other physicists, who are just as ignorant of biology as he, but see that it's about equivalent to the other papers on evolution by physicists. They publish it.
6. The paper is read by other physicists, because at least it's not another derivation of specific heats on some convoluted lattice under a Hamiltonian named for some Central European worthy now otherwise totally forgotten. Said physicists think this is cutting-edge evolutionary theory.
7. Some of those physicists will know or discover simple, neat models with lots of variables of the same type.

A number of observations seem called for.

First, an analogous process in another field of cogno-intellectual ecology has recently been postulated and experimentally documented by a respected statistical physicist (Sokal (1996a,b)). This can only lend support to our model.

Second — and we confess this is a flaw from the aesthetic point of view — our model is not completely detached from the existing literature on the evolution of ideas. While not strictly a memetic theory in the sense of Dawkins (1976) and Lynch (1996), it is very close in spirit to the "epidemiology of ideas" proposed in Sperber (1996). We do not assume any very high degree of similarity between the simple models of evolution, *i.e.*, they are not reliable replicators. Quite the contrary, our model predicts that, to within an order of magnitude, there will be as many distinct models as there are modelers (allowing for collaborations and the proposal of multiple models). Since the models acquire relevance (in the sense of Sperber (1996); Sperber and Wilson (1995)) through distinctiveness and novelty, it could hardly be otherwise.

Third, our model predicts that simple statistical-physical models of evolution will continue to proliferate until either (a) all the available models are exhausted, or (b) they become as common and as boring as any other subject in the statistical physics literature, or (c) physicists learn some actual biology. We are not entirely confident that the third limiting factor will become operational before the others.

Finally, the astute reader of this note will also see that we have not ourselves taken a statistical mechanics approach to modeling the dissemination and diversification of physicists' evolutionary models, but have rather left this as an exercise for subsequent modelers of models of models, though we suspect a multiplicative noise process would be both appropriate and apt. We are strengthened in this suspicion by a recent investigation Redner (1998) into the distribution of citations of papers, independent of their subject matter, found that they conform to Zipf's law with an exponent of  $\approx -0.5$ , and the classical explanation of such phenomena, first provided by Simon (1955), is, precisely, multiplicative noisy growth. Thus, were the field of modeling modelers to come into existence, it would be rife with potential for publication.

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