Does self-assembly design have a built-in Occam's razor?

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1. Abstract

The space of possible designs for self-assembly is unimaginably vast. Here I will argue that randomly picking designs leads to an exponential bias towards simple self-assembled structures. The basic intuition follows from an algorithmic twist on the infinite monkey theorem. If the monkeys type at random in a computer language, they will preferentially produce outputs that can be generated by shorter algorithms. This intuition can be formalised with algorithmic information theory and predicts that random designs are exponentially more likely to produce simpler phenotypes with low descriptional (Kolmogorov) complexity. This principle holds both for artificial design of self-assembling structures, and for Darwinian evolution of self-assembled structures [2], where the fact that evolutionary dynamics does not reach steady-state plays an important role [3]

[1]Designing the self-assembly of arbitrary shapes using minimal complexity building blocks
Joakim Bohlin, Andrew J. Turberfield, Ard A. Louis, Petr Šulc, ACS Nano 17, 6, 5387 (2023)
[2] Symmetry and simplicity spontaneously emerge from the algorithmic nature of evolution
Iain G Johnston, Kamaludin Dingle, Sam F. Greenbury, Chico Q. Camargo, Jonathan P. K. Doye, Sebastian E. Ahnert, Ard A. Louis, PNAS 119, e2113883119 (2022).
[3] The arrival of the frequent: how bias in genotype-phenotype maps can steer populations to local optima
Steffen Schaper and Ard A. Louis, PLoS ONE 9(2): e86635 (2014)