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Scaling laws describe memories of host-pathogen riposte in the HIV population[1] JOHN BARTON, MEHRAN KARDAR, ARUP CHAKRABORTY, Massachusetts Institute of Technology — The enormous genetic diversity and mutability of the human immunodeficiency virus (HIV) has prevented effective control of this virus by natural immune responses or vaccination. Evolution of the circulating HIV population has thus occurred in response to diverse, ultimately ineffective, immune selection pressures that randomly change from host to host. We show that the interplay between the diversity of human immune responses and the ways that HIV mutates to evade them results in distinct sets of sequences defined by similar collectively coupled mutations. Scaling laws that relate these sets of sequences resemble those observed in linguistics and other branches of inquiry, and dynamics reminiscent of neural networks are observed. Like neural networks that store memories of past stimulation, the circulating HIV population stores memories of host-pathogen combat won by the virus. We describe an exactly solvable model that captures the main features of the sets of sequences, and a simple mechanistic model for the origin of the observed scaling laws. Our results define collective mutational pathways used by HIV to evade human immune responses, which could guide vaccine design.

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John Barton
Massachusetts Institute of Technology

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