The Physics of Evolution

November 19, 2014

Introduction

Did you know that principles and equations from physics can be used to study evolution? We'll describe how physics-based models can be used to predict evolution, on the level of individual molecules and whole populations. First, Jeong-Mo will explain how physical modeling can be used to describe and predict real-world phenomena and will introduce the history of evolutionary ideas. Though these two topics may seem unrelated, their relationship will become clear in the following talks. Next, Bryan will show us examples of bacterial evolution in action (data from his own research!) and describe how he uses physics and mathematics to make sense of his results. Finally, Amy will explain how evolution originates from changes in molecules and how all of this relates to the prevalence of human diseases such as sickle cell anemia, and much more. Join us afterwards to look at Bryan's bacterial evolution experiments and for a demo of the computer simulations that we use to study evolution.

Speakers

Jeong-Mo Choi is a 4th-year Ph.D. candidate in the Department of Chemistry and Chemical Biology at Harvard University. His research interests lie in theoretical and computational biophysics and the evolution of protein molecules. Concurrently, he is pursuing an A.M. in the History of Science, with an interest in the acceptance and propagation of new scientific ideas in different cultural and social contexts, also from Harvard. Jeong-Mo originally came from South Korea, where he received a double B.S. in Chemistry and Physics at KAIST.

Bryan Weinstein is a third year Applied Physics graduate student at Harvard University. Bryan studies spatial evolutionary dynamics in the labs of David Nelson, a theoretical condensed matter physicist, and Andrew Murry, an experimental biologist. Bryan's graduate education is graciously supported by the Department of Energy Office of Science and by Harvard's Pierce Fellowship. Bryan is from Fairport, New York (a suburb outside Rochester, New York) and went to Case Western Reserve University for his undergraduate degree in Engineering Physics.

Amy Gilson is a fourth year PhD student in the Chemical Physics program here at Harvard. She is interested in how random, microscopic genetic mutations plus natural selection give rise to big changes in an organism's biology or ecology over time. Her research in Dr. Eugene Shakhnovich's group uses bioinformatics and computer simulations of evolution to study a key aspect of this problem, protein evolution. Outside of the lab, Amy enjoys browsing reddit, running, and singing in the graduate student choir.

Glossary of Important Terms

Population – a group of organisms that evolves over time

Fitness – the chance of reproducing in the next generation

Selective advantage – an increased capacity to reproduce relative to other organisms in the population

Mutation rate – the rate at which mutations occur in the DNA. Over time, mutations and selection can lead to new traits.

Genome – the DNA blueprint of an organism, consisting of many genes

Gene – a stretch of DNA that codes for a single protein

Genotype – the kinds of genes in an organism

Phenotype – an organism's observable traits. Different genotypes give rise to different phenotypes, e.g., hair color, or fitness

Fitness function – the relationship between an organism's genotype and its phenotype

Resources to learn more

NIH Curriculum Supplement on Evolution and Medicine,
https://science.education.nih.gov/customers.nsf/HSEvolution.htm
Evolving Soft Robots: http://creativemachines.cornell.edu/soft-robots
Lenski Long-Term Evolution Experiment, http://myxo.css.msu.edu/ecoli/publicinterest.html
Past SITN seminar: How Evolution Generates "Endless forms, Most Beautiful,"
http://sitn.hms.harvard.edu/seminars/2012/how-evolution-generates-endless-forms-most-beautiful/
Shakhnovich Group website, http://faculty.chemistry.harvard.edu/shakhnovich
Murray Lab website, http://labs.mcb.harvard.edu/murray/

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Science by the Pint, 7pm at The Burren

Dec 8, Dr. Caspar Hare

Jan 12, Dr. Michael Brenner

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