

Systems Generational Evolution

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Overview

- Application of biological evolution models to systems development in search of a “natural” evolution in the design process.
- Analysis of missteps in system evolution process to obtain a better understanding of how the system evolved.

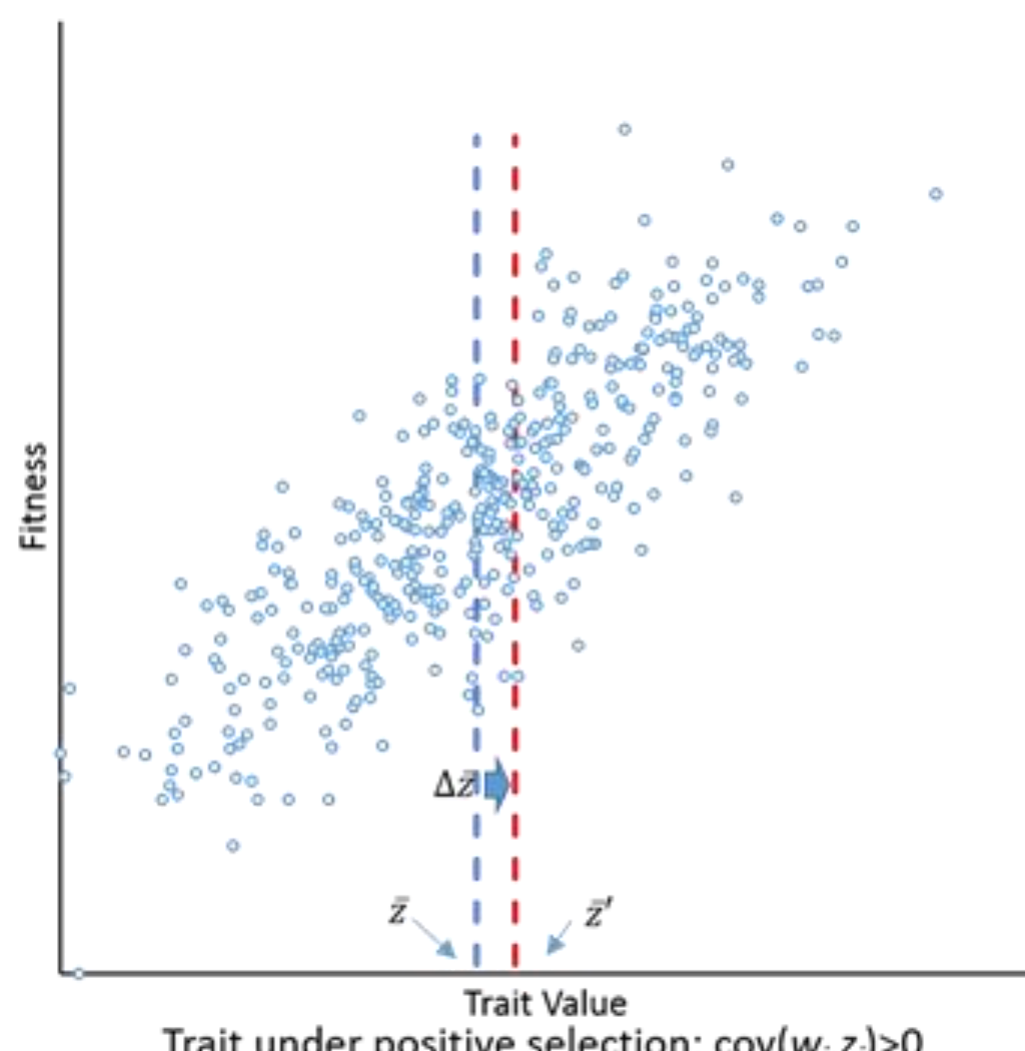
Potential Biological Models Applicable to Systems

Hardy-Weinberg Equation:

$$p^2 + 2pq + q^2 = 1$$

B= dominant allele, b= recessive allele
p = BB + .5 Bb, q = bb + .5 Bb

	Father's Genes	
	B	b
Mother's Genes	B	Bb
	b	Bb
		bb

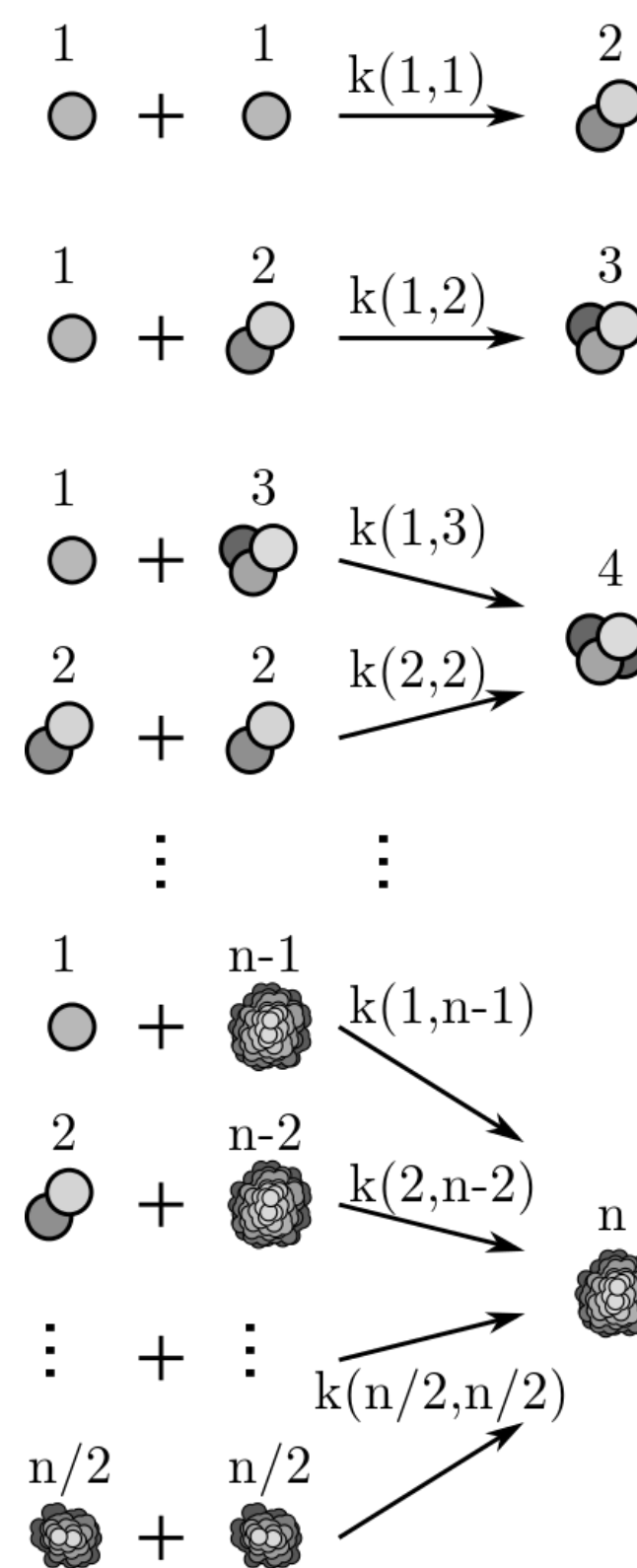


Price Equation:

$$w_{avg} \times \Delta_{z_{avg}} = COV(w_i, z_i) + E(w_i \times \Delta_{z_i})$$

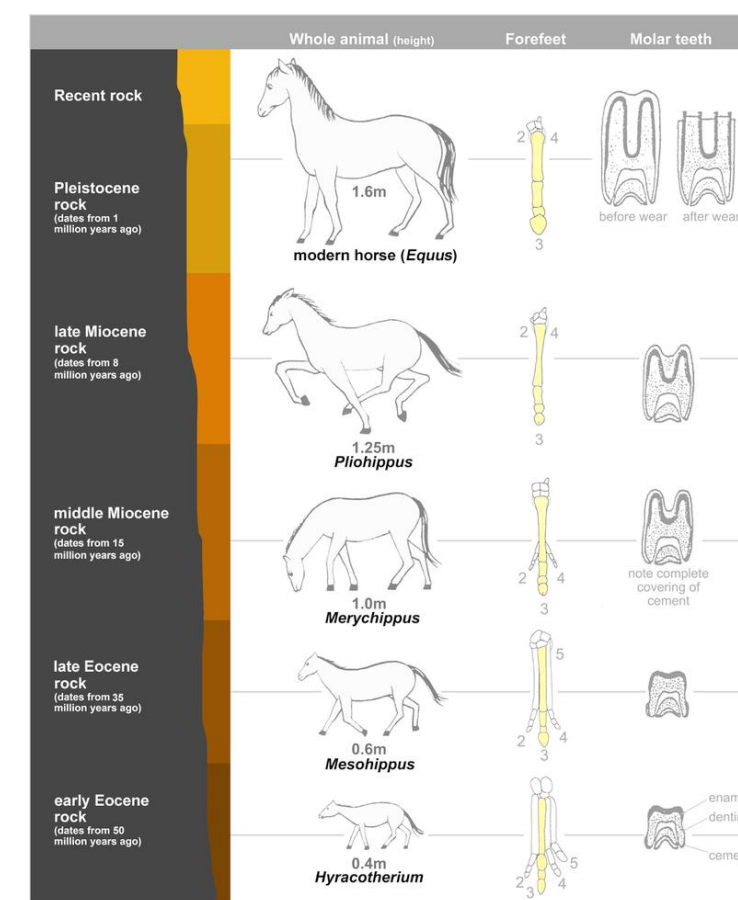
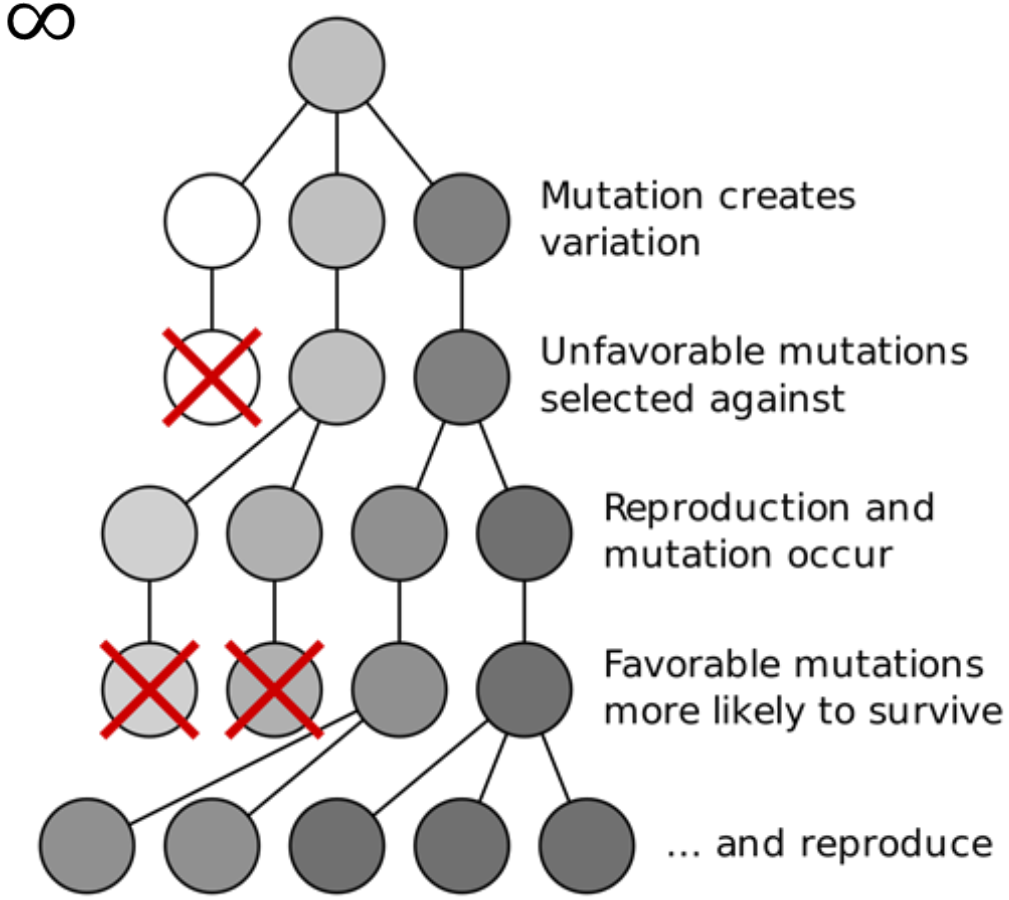
Smoluchowski Equation:

$$\frac{\partial p}{\partial t} = \frac{1}{2} \mu \nabla \cdot (\nabla p(\xi) - 4N_e p(\xi) V \Phi(\xi))$$



“In Parallel” Process:

$$\frac{\log L}{\log\left(\frac{K}{K-1}\right)} + \beta(L) + O(L^{-1}), \quad L \rightarrow \infty$$



Haldanes:

$$rate(h) = \frac{\bar{z}_2 - \bar{z}_1}{t_2 - t_1} = \frac{\ln x_2}{S \ln x} - \frac{\ln x_1}{S \ln x} = \frac{\ln x_2 - \ln x_1}{t_2 - t_1}$$

Applications to Systems Engineering

- Infusion of new technology to an existing system
- Impacts of technology forecasting
- Fitness landscape evaluations across generations

Impact

- Potential applications for this concept are systems and platforms that are anticipated to be in service for several generations, such typified to date by the Lockheed C-130 Hercules and projected for future cyber-physical systems.
- SGE gives insight into how to design such multi-generational systems will help future generations of systems evolve with changing missions and the infusion of new technology more fluidly.

Future Work

Key items to investigate in pursuing this new idea are looking at how non-natural elements affect the evolution of a system, creating a classification of systems of systems, using design structure matrices to visualize SGE, creating of an SGE mathematical model and answering the following:

1. How can the model optimize the risk to reward to reward ratio in systems engineering design?
2. How is inherent uncertainty incorporated?

Acknowledgements

Katherine Burris would like to thank Dr. L. Dale Thomas for the idea and guidance in systems generational evolution. Special thanks also goes to Dr. Paul Collopy, Dr. Bryan Mesmer and her fellow graduate researchers for feedback and support.