

THE ORIGINS OF CELLULAR ARCHITECTURE

INTRODUCTION

1. Evolutionary Cell Biology.

- The dominance of unicellular life.
- What is evolutionary cell biology?
- The completeness of evolutionary theory.
- Nonadaptive hypotheses and our understanding of evolution.
- The grand challenges.
 - The origin of life.
 - The roots of organismal complexity.
 - Molecular stochasticity.
 - Molecular complexes.
 - Cellular networks.
 - Cellular surveillance systems.
 - Growth regulation.
 - Biological scaling laws.

2. The Origin of Cells.

- The earliest stages.
 - The alkaline hydrothermal-vent hypothesis.
 - The terrestrial geothermal-field hypothesis.
- An early RNA world?
- Membranes and the origin of individuality.
- Genomic constraints on the establishment of life.

3. The Major Lines of Descent.

- The major domains of life.
- Times of origin.
- The emergence of eukaryotes.
 - The stem eukaryote.
 - The eukaryotic radiation.
 - A eukaryotic big bang?

THE GENETIC MECHANISMS OF EVOLUTION

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- The genetic effective sizes of populations.
- Probability of fixation of a mutant allele.
- Evolution of the mutation rate.
 - High mutability of mutation rates.

- Error-prone polymerases.
- Optimizing the mutation rate.
- The nonrandom nature of mutations.

Recombination.

- Evolution of the recombination rate.

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- The perils of the adaptive paradigm.
- The fitness effects of new mutations.
- The classical model of sequential fixation.
- Vaulting barriers to more complex adaptations.
 - Sequential fixation vs. stochastic tunneling.
 - Two-locus transitions.
 - More complex scenarios.
 - The effects of recombination.
- The phylogenetic dispersion of mean phenotypes.
 - Two-state traits.
 - Multistate-traits and the drift-barrier hypothesis.

6. Evolution of Cellular Complexity.

- Illusions of grandeur.
- Constructive neutral evolution.
 - Ribosomes.
- Evolution by gene duplication.
 - The masking effect.
 - Neofunctionalization.
 - Subfunctionalization.
 - Adaptive-conflict resolution.
- The case for subfunctionalization.
- The emergence of modular gene subfunctions.
- The passive origin of species via gene duplication.

BASIC CELLULAR FEATURES

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- Molecular composition of cells.
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 - Elemental composition.
 - Biomolecules.
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- Intermolecular encounter rates.
- Temperature-dependence of biological properties.
- Energy, carbon skeletons, and cell yield.

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 - Lessons from phylogenetic comparisons and experimental mutagenesis.
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