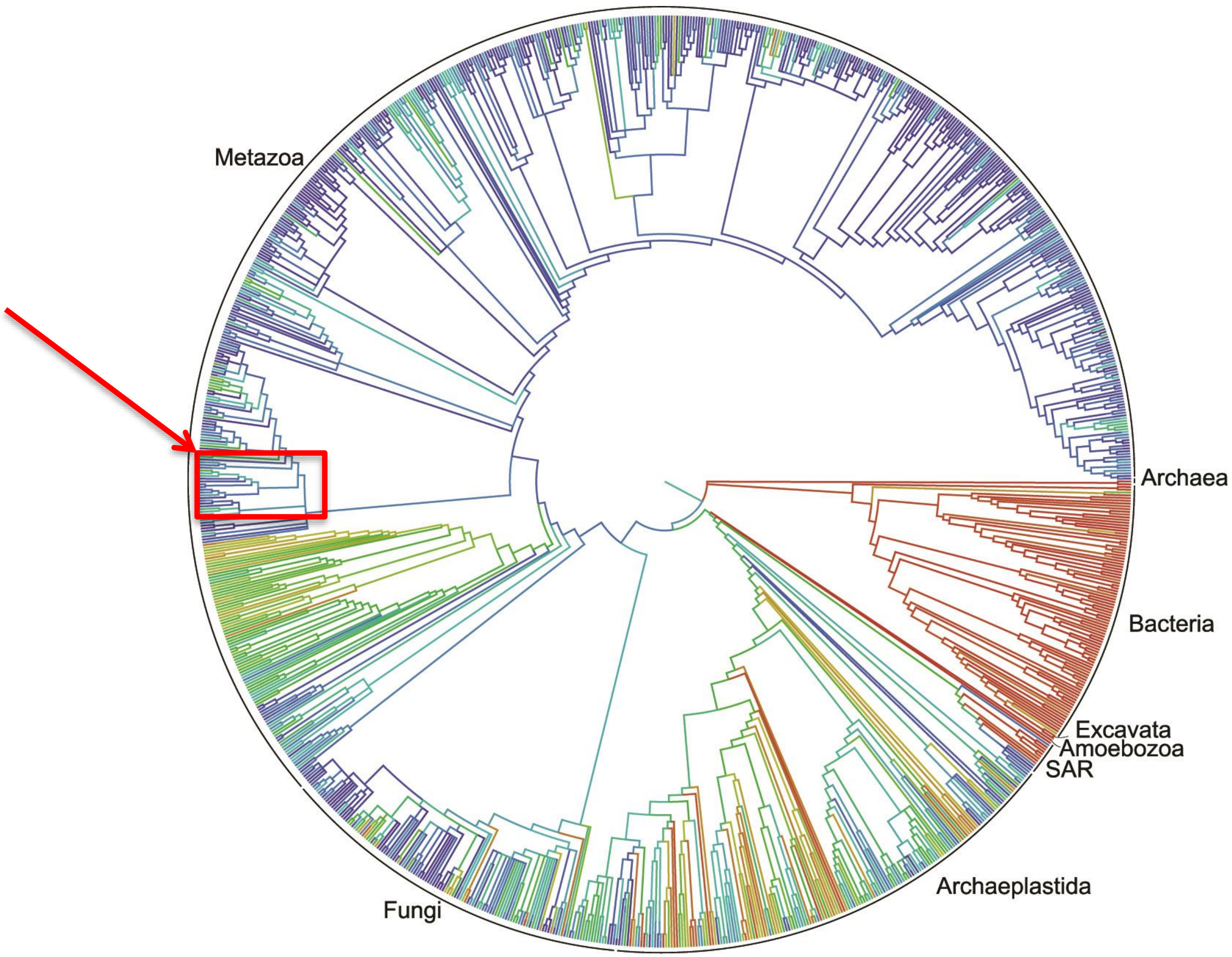
Workshop in Molecular Evolution

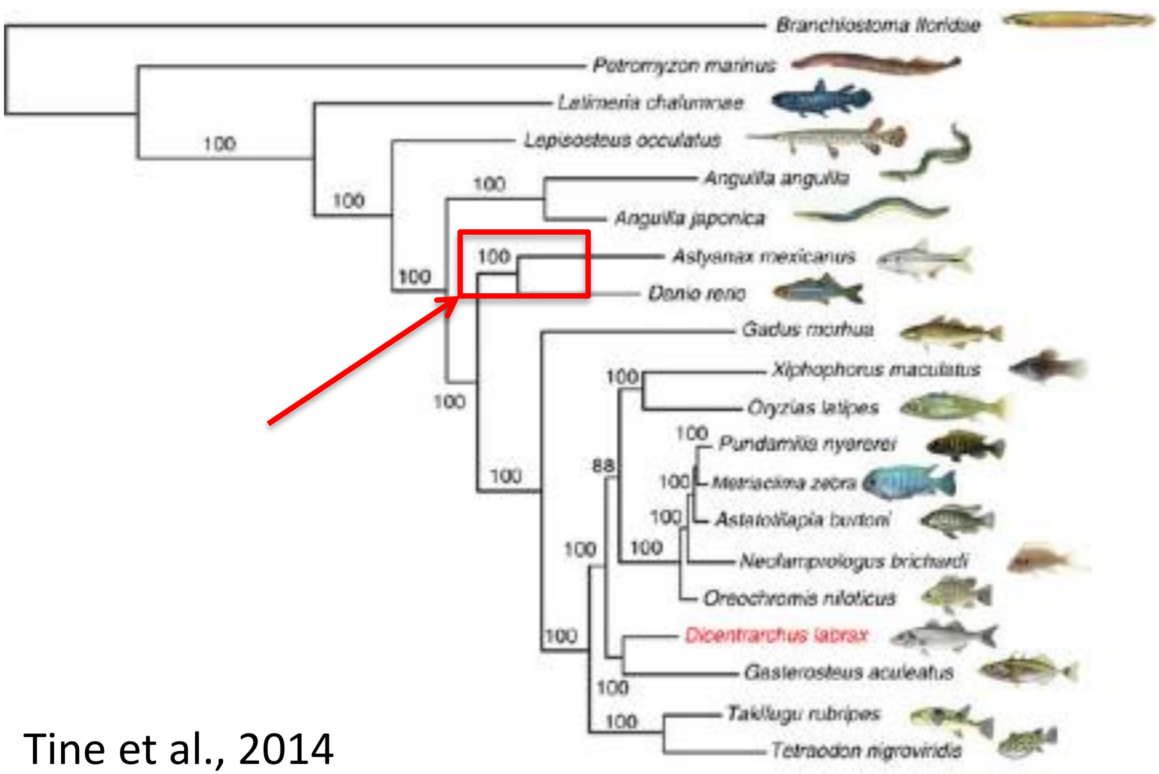
Jan 7 - 11, 2019

Shanghai

Two faces of one process: phylogenetics vs. population genetics

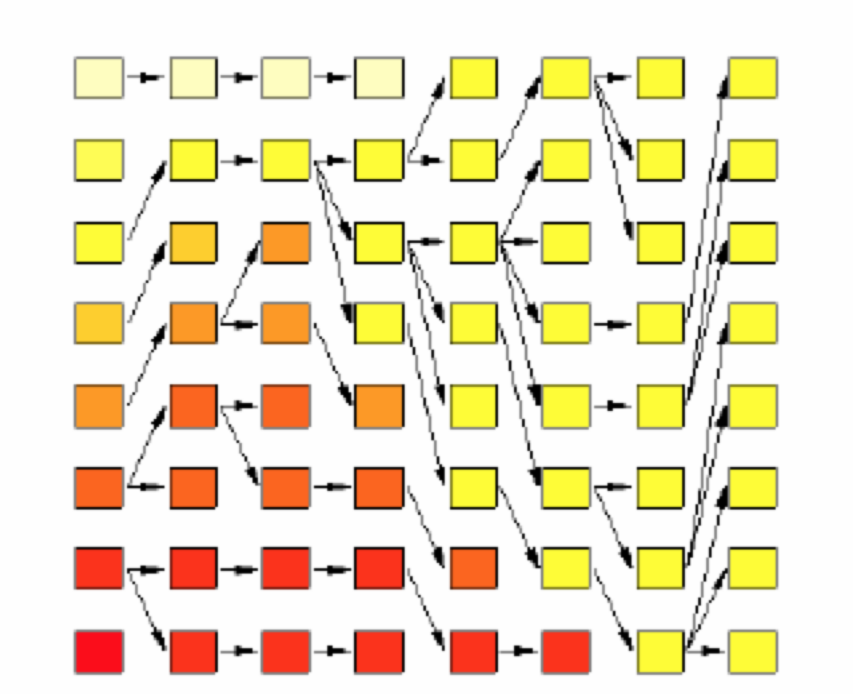


Phylogenetics – model of speciation

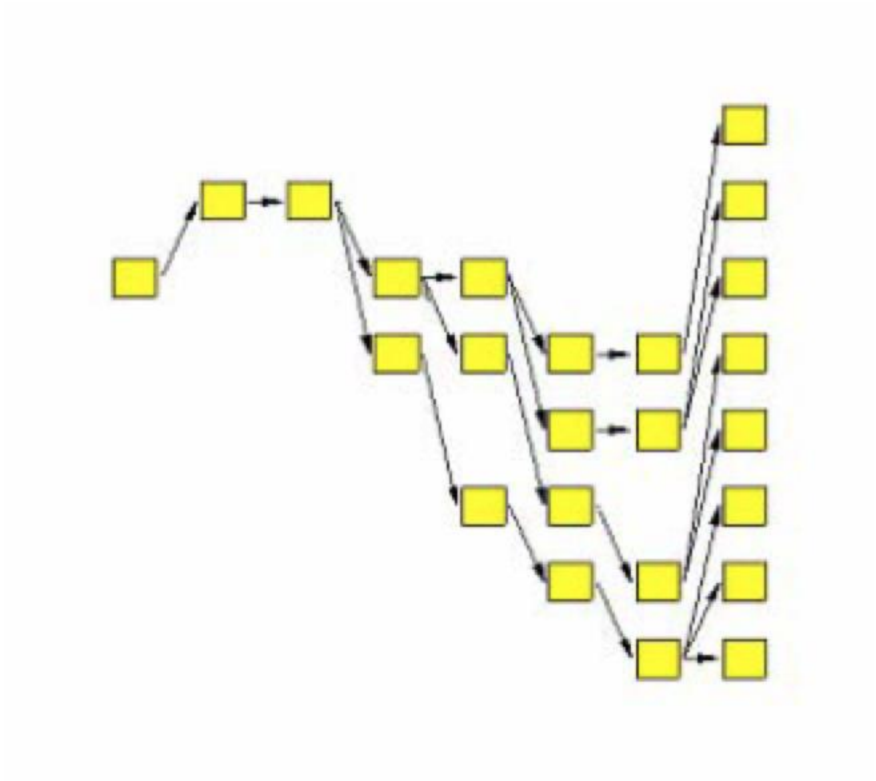


Tine et al., 2014

Population genetics – model of coalescence



Population genetics



Idealised population (Fisher-Wright population)

- Random mating
  - each copy of the gene found in the new generation is drawn independently at random from all copies of the gene in the old generation
- No selection
- No migration
- No mutation
- Large population size, no drifting

Genética De Poblaciones

Sir Ronald A. Fisher
(1890-1962)

Sewall Wright

(1889-1988)

John B. S. Haldane
(1892-1964)

British biologist and statistician Ronald Fisher

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- In a series of papers starting in 1918 and culminating in his 1930 book The Genetical Theory of Natural Selection
- Fisher showed that the continuous variation measured by the biometricians could be produced by the combined action of many discrete genes, and that natural selection could change allele frequencies in a population, resulting in evolution.

British geneticist J.B.S. Haldane

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- worked out the mathematics of allele frequency change at a single gene locus under a broad range of conditions.
- Haldane also applied statistical analysis to real-world examples of natural selection, such as peppered moth evolution and industrial melanism

The typical white-bodied form of the peppered moth.

Industrial melanism: the black-bodied form of the peppered moth appeared in polluted areas.

The American biologist Sewall Wright

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- animal breeding experiments, focused on combinations of interacting genes, and the effects of inbreeding on small, relatively isolated populations that exhibited genetic drift.
- In 1932 Wright introduced the concept of an adaptive landscape and argued that genetic drift and inbreeding could drive a small, isolated sub-population away from an adaptive peak, allowing natural selection to drive it towards different adaptive peaks.

Idealised population (Fisher-Wright population)

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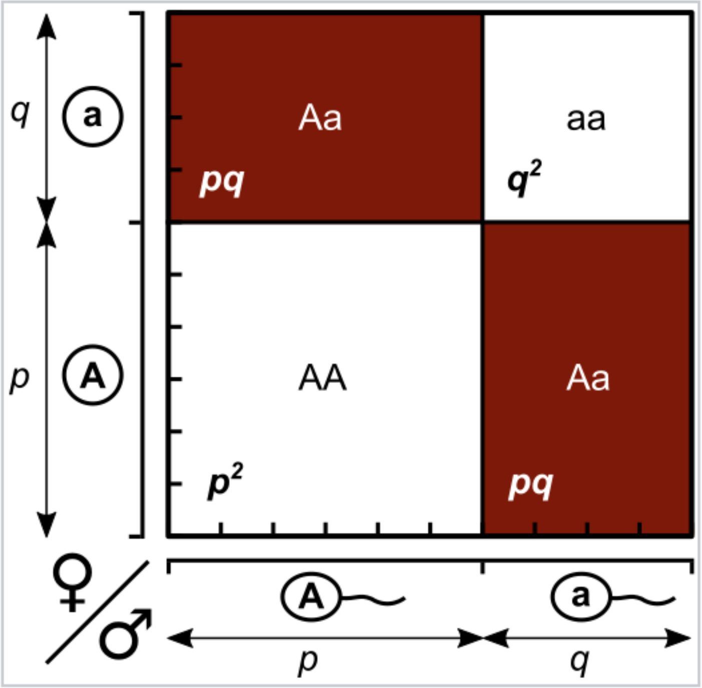
Idealised population (Fisher-Wright population)

- Hardy-Weinberg equilibrium
  - allele frequencies stay constant over time, genotype frequencies are related to allele frequencies
- Linkage equilibrium

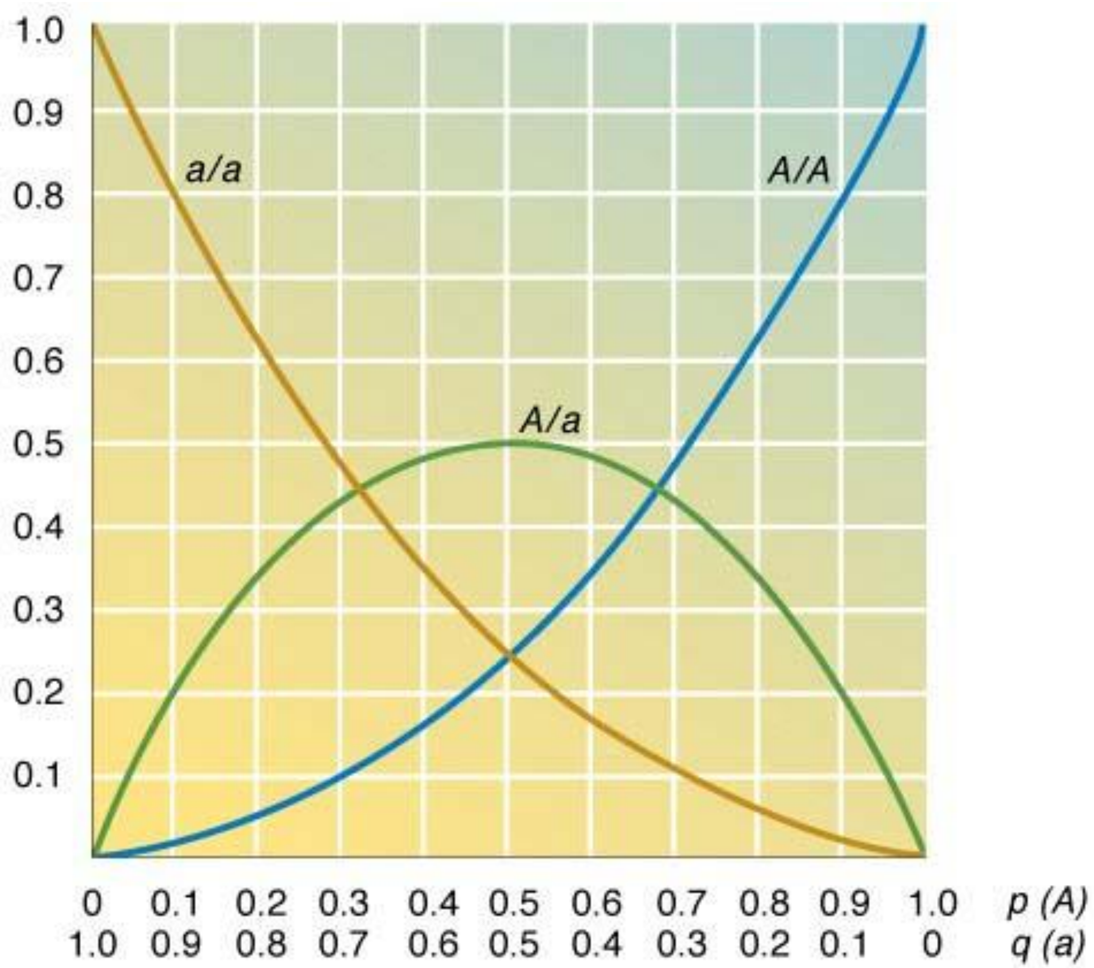
Hardy-Weinberg equilibrium



Length of p, q corresponds to allele frequencies (here $p = 0.6$, $q = 0.4$). Then area of rectangle represents genotype frequencies (thus $\mathrm{AA : Aa : aa} = 0.36 : 0.48 : 0.16$).

One locus with 2 alleles at HWE: $p^2 + 2pq + q^2 = 1$

Implications of HWE (two-allele locus)



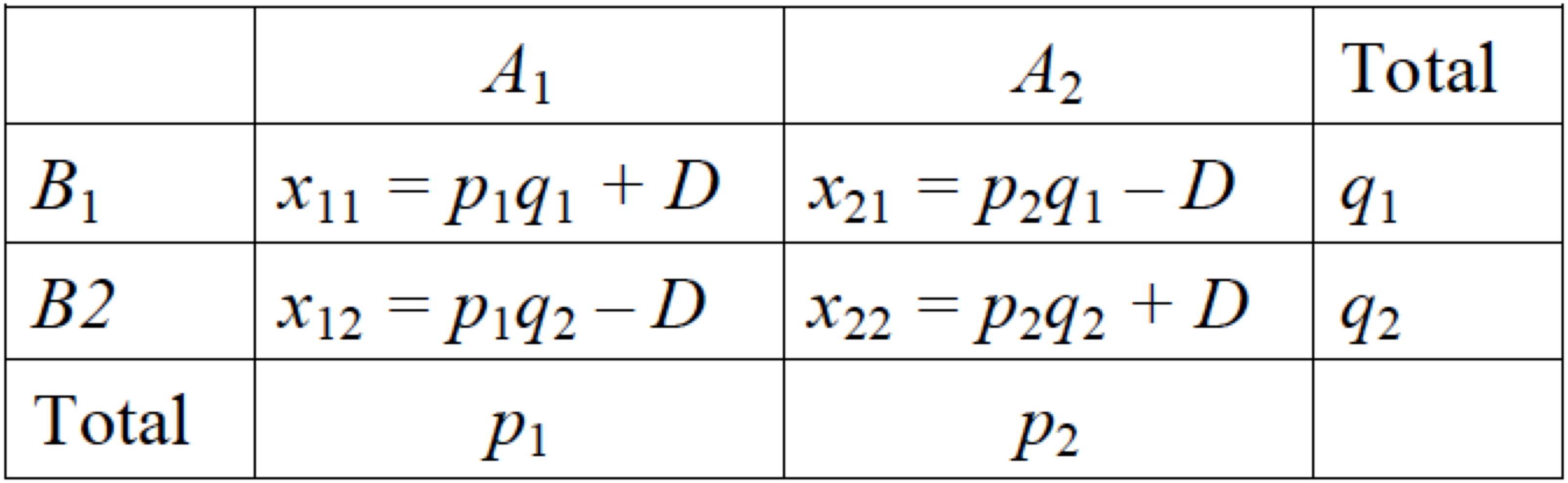
- Rare alleles mostly in heterozygotes
- Common ones mostly in homozygotes
- Maximum *He* is 0.5 at 2 allele locus, rising to 1.0 with more alleles

Linkage equilibrium

- Alleles at separate loci are expected to segregate independently during meiosis. They show **linkage equilibrium**.

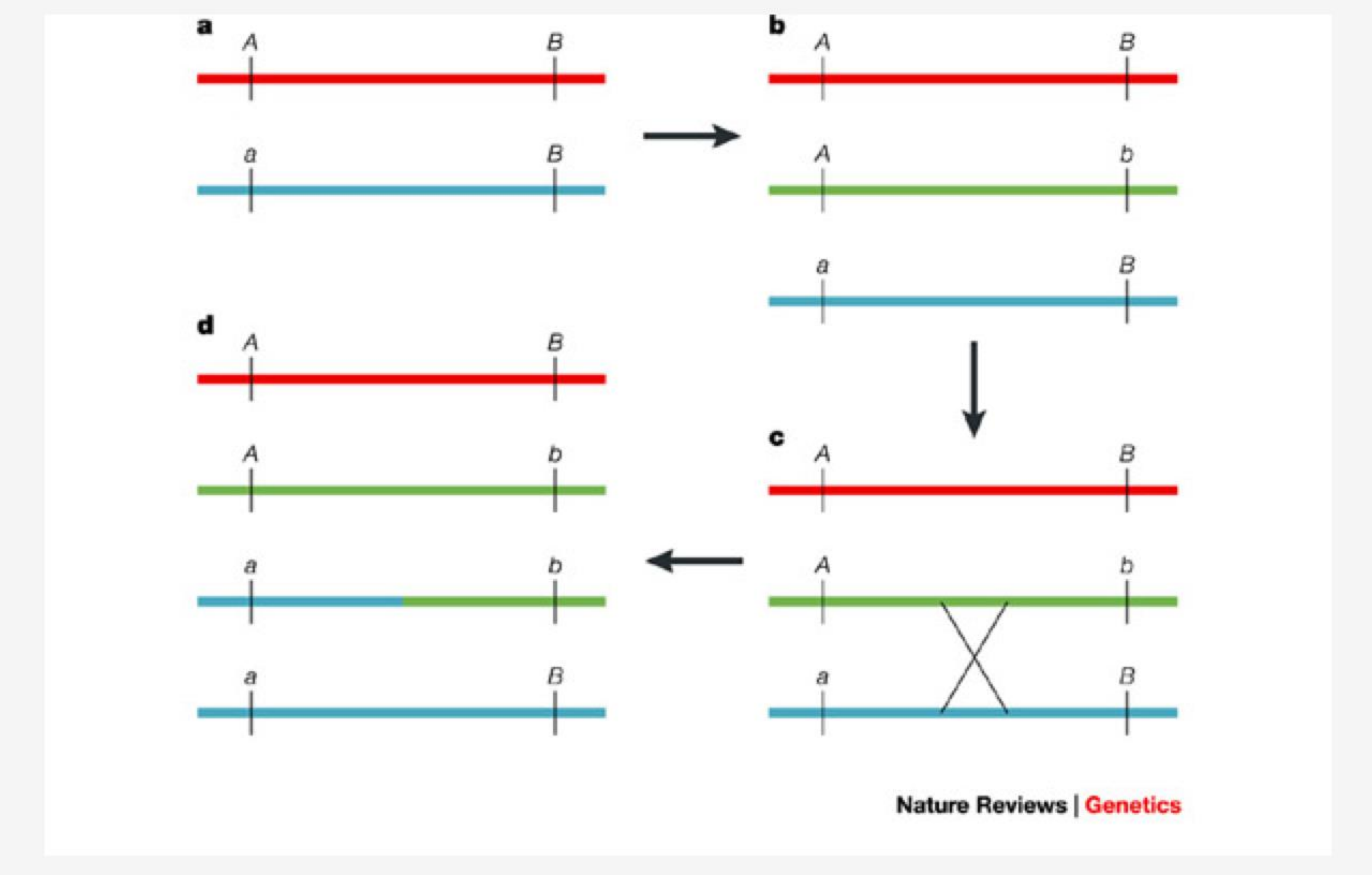
Example:

- 2 loci with alleles A_1 and A_2; B_1 and B_2 their frequencies will be p_1 *and* p_2 *and* q_1 *and* q_2.
- Possible gametes A_1B_1; A_1B_2; A_2B_1; A_2B_2
- Genotype frequencies will be the product of constituent allele frequencies



	A_1	A_2	Total
B_1	$x_{11} = p_1q_1 + D$	$x_{21} = p_2q_1 - D$	q_1
$B2$	$x_{12} = p_1q_2 - D$	$x_{22} = p_2q_2 + D$	q_2
Total	p_1	p_2	

Linkage disequilibrium



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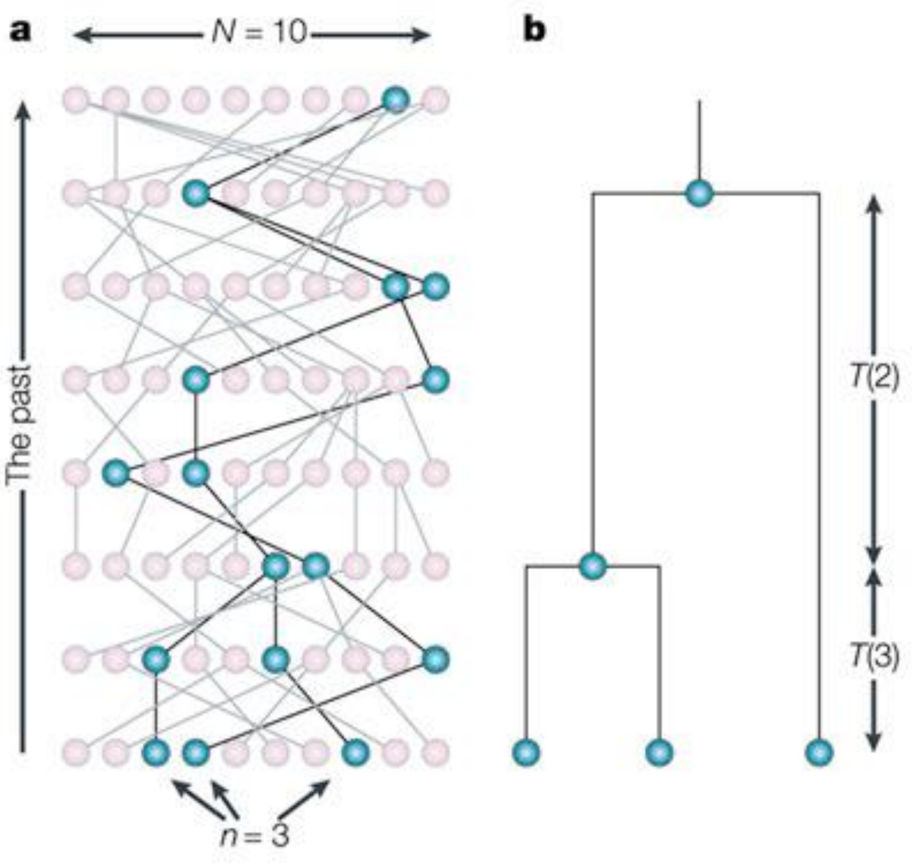
Linkage disequilibrium

***Linkage disequilibrium** = a deviation from random associations of alleles at different loci*

- Linkage disequilibrium can be caused by :
  - - chance events
  - - population bottlenecks
  - - recent mixing of different populations
  - - selection
- Linkage disequilibrium is important because:
  - - It is common in threatened species with small populations
  - - evolutionary processes are altered
  - - functionally important genes may exhibit linkage disequilibrium
  - - can be a signal of recent admixture of populations

Coalescent theory



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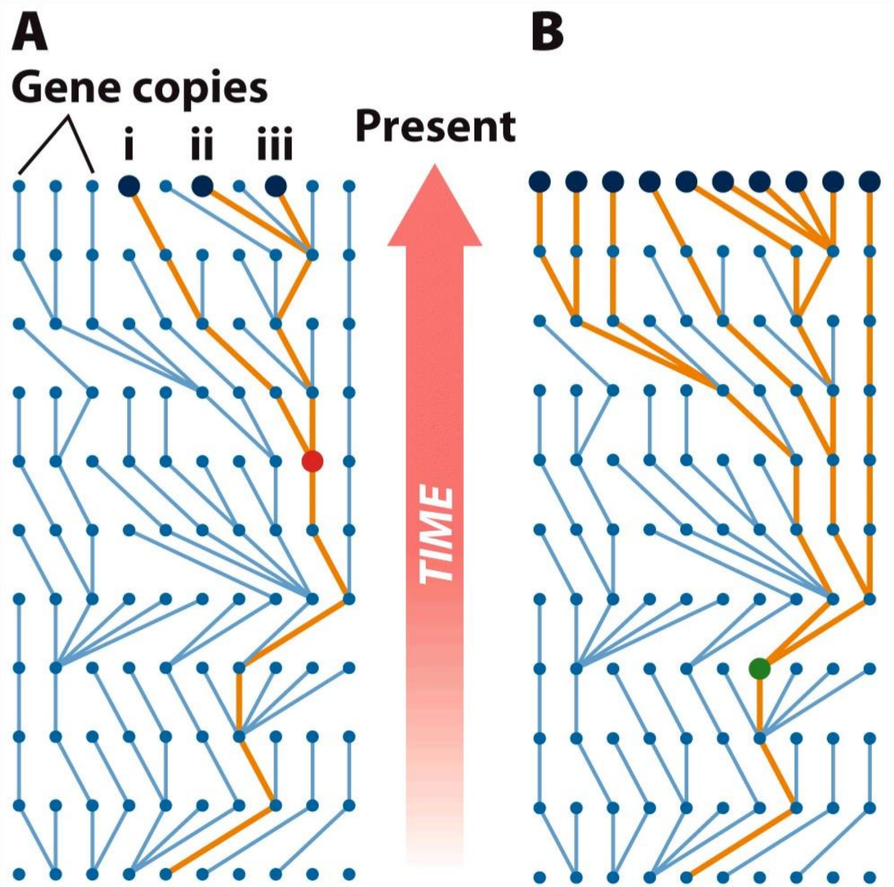
Sampling for coalescent analysis



Evolution, 1/e Figure 8.14
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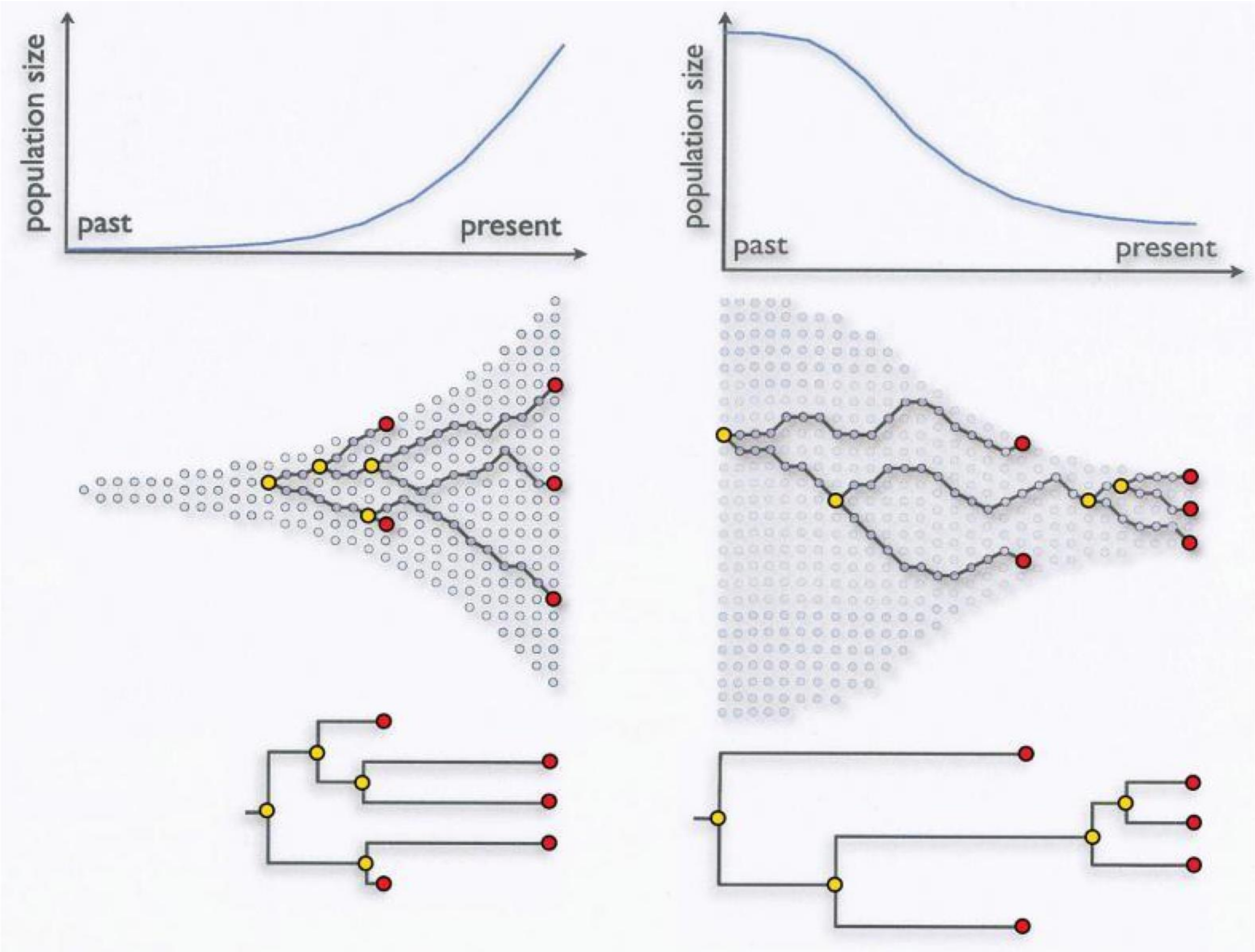
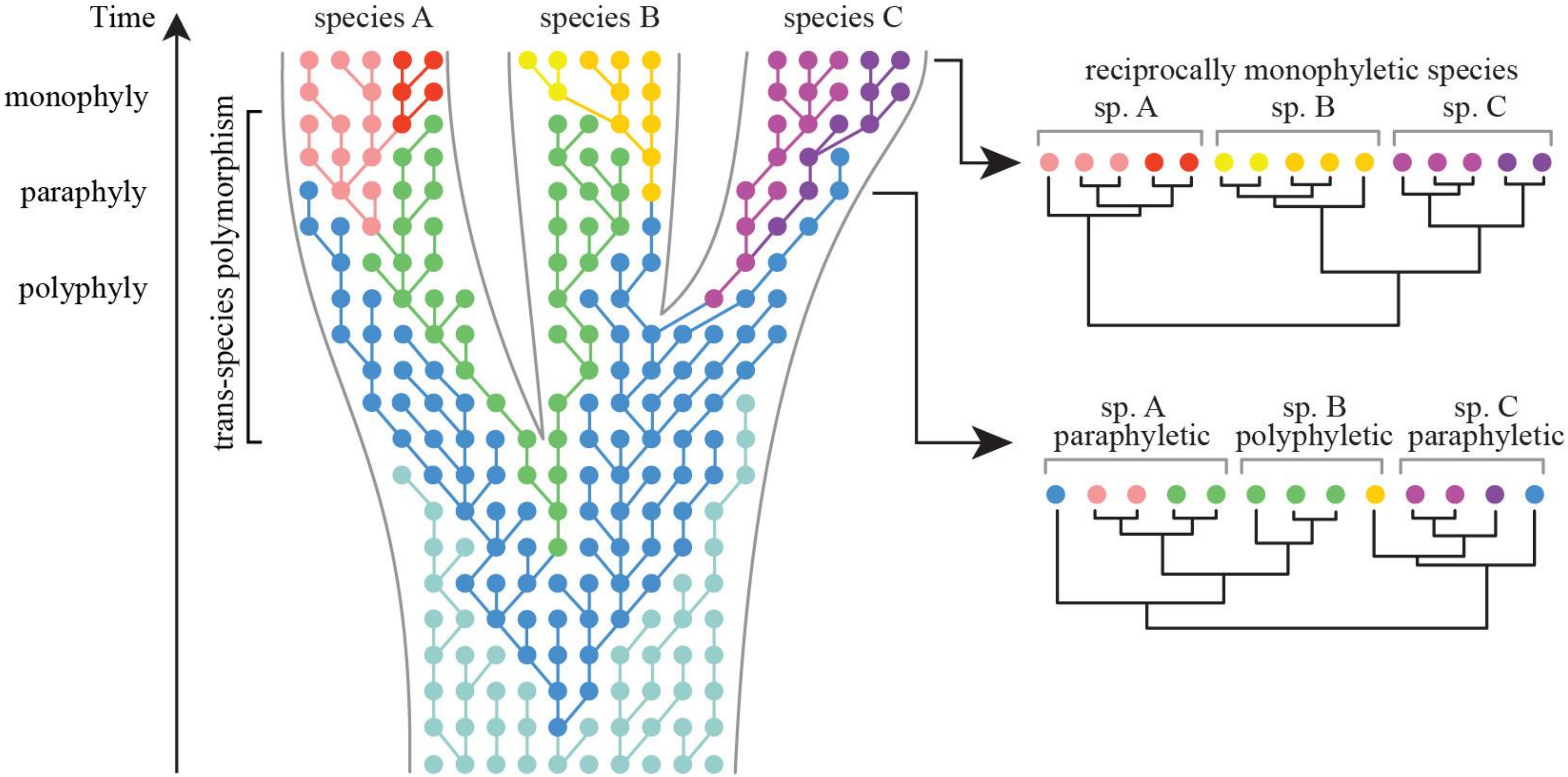
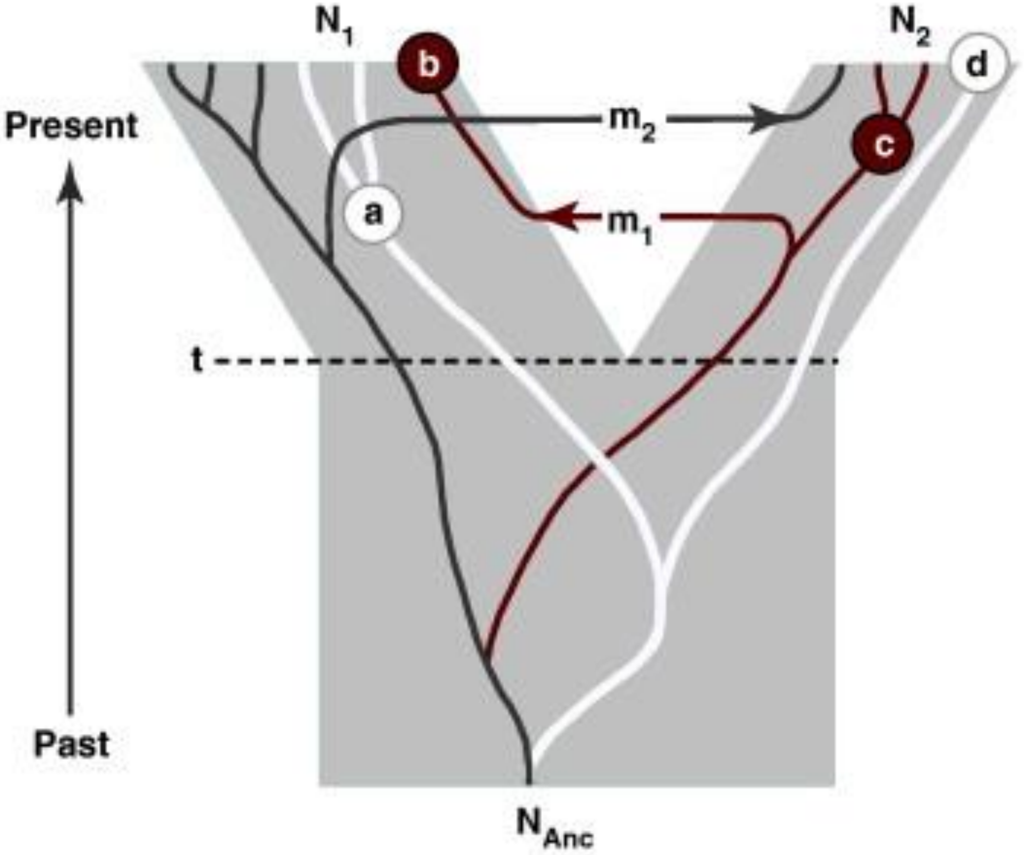
Population growth



Species delimitation



Migration



TRENDS in Ecology & Evolution

Thank you!