A coalescent tree of copies of genes

... such as you get if there is has been no recombination. (We will discuss the theory of coalescents much later in the course).
If there is a mutation in locus A

ab  Ab  Ab  Ab  Ab  ab  ab  ab  ab  ab

It exists in a clade on the tree.
... and one also in locus B

It exists in another clade,
... or else where on the tree

... or within the first clade,
... and even below the $A$ clade

... and can also have its clade include the clade for the first mutation.
So you get only three haplotypes

The presence of three haplotypes is the sign that there need not have been any recombination. This is called the “three-gamete test”.

- You can get both alleles at both loci from only two mutational events, and ...
- each creates one additional haplotype, so there is a total of 3 haplotypes, in which case
- ... the $D'$ measure of linkage disequilibrium is $\pm 1$, 
- ... so a perfect treelike genealogy goes along with LD as strong as possible, 
- ... in other words, “trees and $D$’s” are telling you the same thing.
John Burdon Sanderson Haldane (1892 – 1964)

in the late 1930s

in the 1940s
JBS Haldane’s achievements include ...

- First to make tables of mixtures of gases for deep diving
- First genetic mapping function (the Haldane Mapping Function, 1919)
- Fundamental work in biochemical kinetics
- In population genetics, basic equations for natural selection, migration, mutation
- Pioneered use of likelihood methods in linkage estimation
- One of first two to suggest (with Oparin) that the earth’s early atmosphere was reducing
- Early estimate of rate of mutation of a human gene
- Advised British Admiralty on construction of World War II mini-submersibles
- Science popularizations
Selection with haploids or multiplicative fitnesses

Course of gene frequency change in haploid selection with initial gene frequency $p_0 = 0.01$ and relative fitness 1.2 of the $A$ genotype.
Selection with dominance and recessiveness

Change of the gene frequency plotted against gene frequency of $A$ for cases in which the favored allele is dominant (D), multiplicative (M) and recessive (R). Fitnesses of $AA : Aa : aa$ genotypes were respectively 2.3 : 2.3 : 1, 5.29 : 2.3 : 1, and 2.3 : 1 : 1.
Change of gene frequency with or without dominance

The course of gene frequency change over 50 generations when fitnesses of AA, Aa, and aa are 2.3 : 2.3 : 1 (circles) and 2.3 : 1 : 1 (squares). Initial frequency of A is 0.02.
The change in gene frequency ($\Delta p$) plotted against the gene frequency in a case of overdominance where fitnesses of $AA : Aa : aa$ are $0.85 : 1 : 0.7$. 
Gene frequencies with overdominance

Convergence of initial gene frequencies from \( p_A = 0.99 \) and \( p_a = 0.01 \) to equilibrium when the fitnesses of \( AA, Aa \), and \( aa \) are 0.85 : 1 : 0.70
Gene frequencies with underdominance

Gene frequencies in successive generations when fitnesses of $AA$, $Aa$, and $aa$ are underdominant (1.15 : 1 : 1.3) and the initial gene frequency is 0.65(circles) or 0.68 (squares).
Mean fitness in a case of overdominance

Mean fitness plotted as a function of gene frequency when fitnesses are: \( AA \ 0.55, \ Aa \ 1, \ aa \ 0.25. \)
Mean fitness in a case of underdominance

Mean fitness plotted as a function of gene frequency when fitnesses are: $AA \ 1.15$, $Aa \ 1$, $aa \ 1.30$. 
Course of gene frequency change in a numerical example of a case of alternating Wet and Dry years (lighter lines) and in a case of random Wet and Dry years, independently drawn with equal probabilities. In both cases relative fitnesses of $A$ are 1.5 and 0.6 in Wet and Dry years. The starting gene frequency in both cases is 0.5.