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Genetic variation in populations (allele and genotype frequencies), HWE

Modul no.: Animal Genetics

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Erasmus+ project 2021-1-SK01-KA220-HED-000032068

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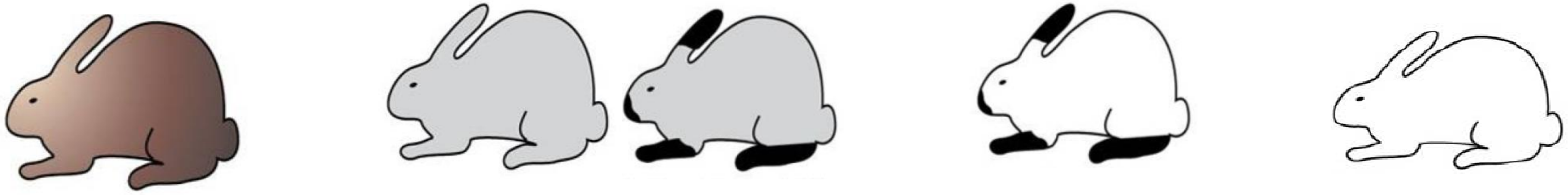
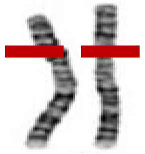
At the level of individuals

Phenotype



wild | chinchilla | himalayan | albino

$c^+ > c^{ch} > c^h > c$



Genotype: one gene – one locus

c^+c^+, c^+c, c^+c^{ch}, c^+c^h | $c^{ch}c$, $c^{ch}c^{ch}$, $\underline{c^{ch}c^h}$ | c^hc^h, cc^h | cc

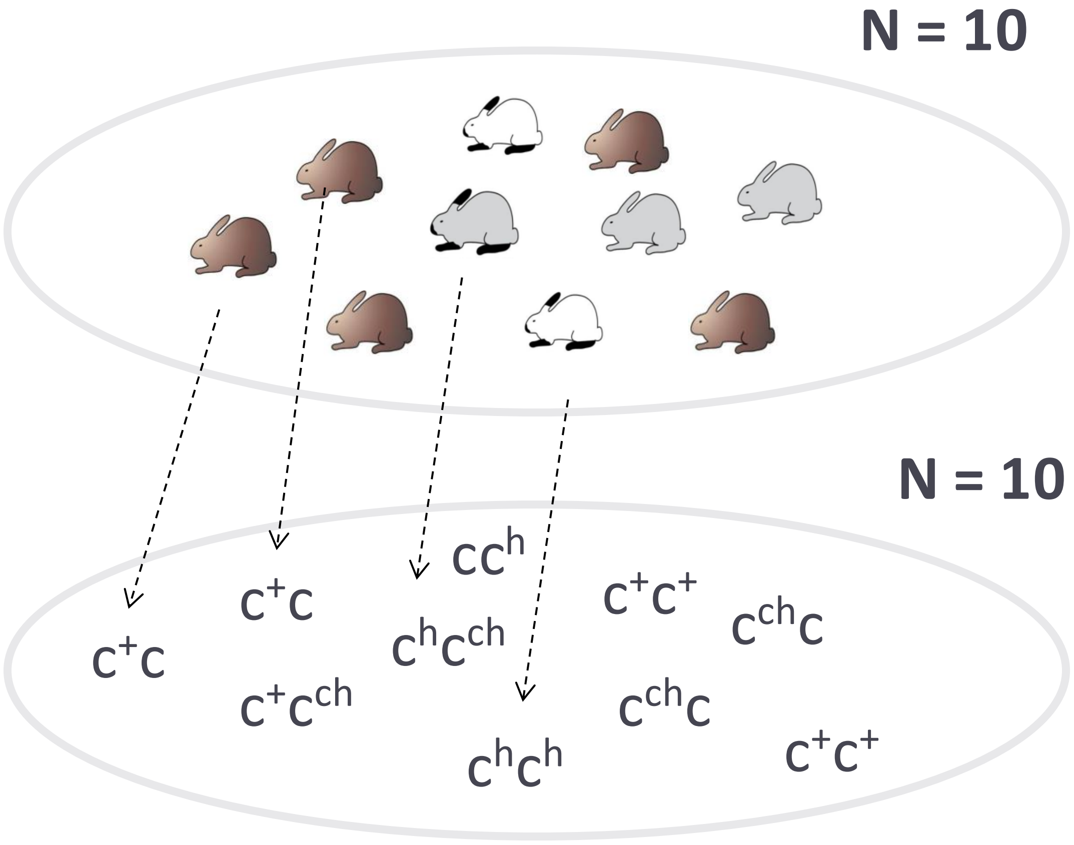
*Note: Even when more than two alleles exists, any given individual can have no more than two alleles (one for the mother and one form the father).

Population level

Alely

c^+ (wild), c (albino),
c^{ch} (chinchila), c^h (himalayan)

10 rabbits → 20 allele:
7 $c^+ (A_1)$, 5 c (A_2),
4 c^{ch}, (A_3) 4 c^h (A_4)



frequency of all. c^+ (**A_1**)= **p** = ? = 7/20 = 0,35

frequency of all. c (A_2)= r = ? = 5/20 = 0,25

frequency of all. c^{ch} (A_3)= w = ? = 4/20 = 0,20

frequency of all. c^h (A_4)= v = ? = 4/20 = 0,20

frequency of all. **A_2**
q = r + w + v
= ? = 13/20 = 0,65

*Note: p + q = 1 (0.35 + 0.65)

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Population 1: polymorphic loci (multialelic: > two alleles)

c^+c cc^h c^+c^+ $c^{ch}c$
c^+c c^+c^{ch} c^hc^{ch} c^hc^h $c^{ch}c$ c^+c^+

N = 10

Population 2: monomorphic loci

c^+c^+ c^+c^+ c^+c^+ c^+c^+ c^+c^+
c^+c^+ c^+c^+ c^+c^+ c^+c^+ c^+c^+

N = 10

Population 3: polymorphic locus (bialletic: only two alleles)

c^+c^h c^+c^h c^+c^+ c^+c^+ c^+c^+ c^hc^h
c^+c^+ c^hc^h c^hc^h c^+c^+

N = 10

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Bialellic locus: $p(A_1)$ & $q(A_2)$:

Base population

$D = A_1A_1 \rightarrow d = \frac{D}{N}$

$H = A_1A_2$ nebo $A_2A_1 \rightarrow h = \frac{H}{N}$

$R = A_2A_2 \rightarrow r = \frac{R}{N}$

$N = D + H + R$

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$R = A_2A_2 \rightarrow r = \frac{R}{N}$

$N = D + H + R$

Frequency of allels

$A_1 \rightarrow p = d + 0{,}5h$

$A_2 \rightarrow q = r + 0{,}5h$

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Bialellic locus: $p(A_1)$ & $q(A_2)$:

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$R = A_2A_2 \rightarrow r = \frac{R}{N}$

$N = D + H + R$

Frequency of allels

$A_1 \rightarrow p = d + 0{,}5h$

$A_2 \rightarrow q = r + 0{,}5h$

Next Generations

$A_1A_1 \rightarrow A_{1♂} \times A_{1♀} \rightarrow p \times p = \mathbf{p^2}$

$A_1A_1 \rightarrow A_{1♂} \times A_{1♀}$ nebo $A_{2♂} \times A_{1♀} = (p \times q) + (q \times p) = \mathbf{2pq}$

$A_2A_2 \rightarrow A_{2♂} \times A_{2♀} \rightarrow q \times q = \mathbf{q^2}$

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Bialellic locus: $p(A_1)$ & $q(A_2)$:

Base population

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$H = A_1A_2$ nebo $A_2A_1 \rightarrow h = \frac{H}{N}$

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$N = D + H + R$

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$A_2A_2 \rightarrow A_{2♂} \times A_{2♀} \rightarrow q \times q = \mathbf{q^2}$

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Hardy-Weinberg equilibrium (HWE)

The Hardy–Weinberg principle states that both allele and genotype frequencies in a population remain constant – that is , they are in ekvilibrium – from generation to generation unless specific disturbing influences are introduced.

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Those distrubind influences include:

Selection,

Mutation

Migracion,

Non-Random Mating,

Genetics Drift (finite population size),

It is important to understand that outside the lab, one or more of these „disturbing influences“ are always in effect.

That is, Hardy-Weinberg Equilibrium is impossible in nature.

Genetic ekvilibrium is an ideal state that provides a baseline to measure genetic change against.

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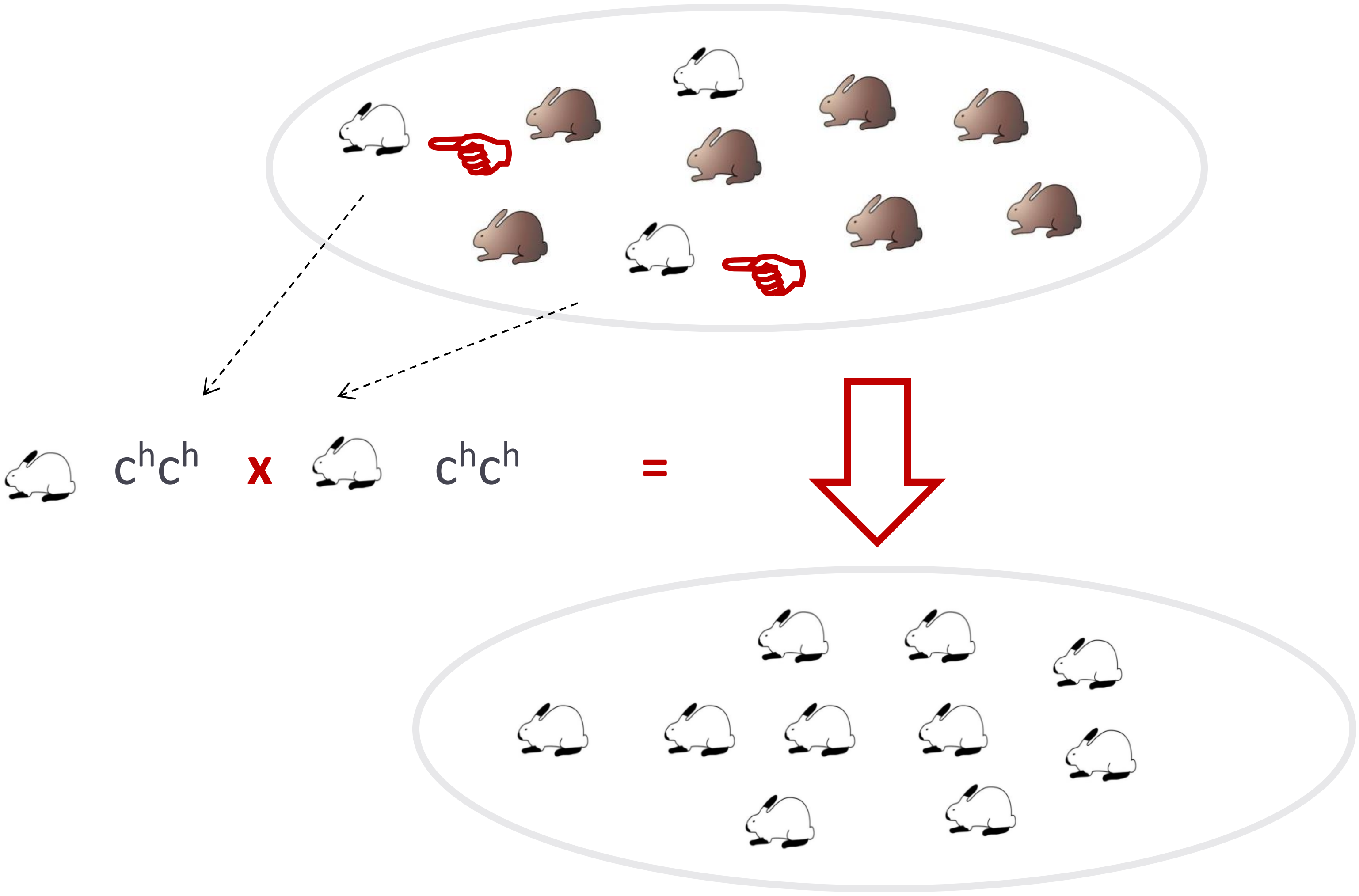
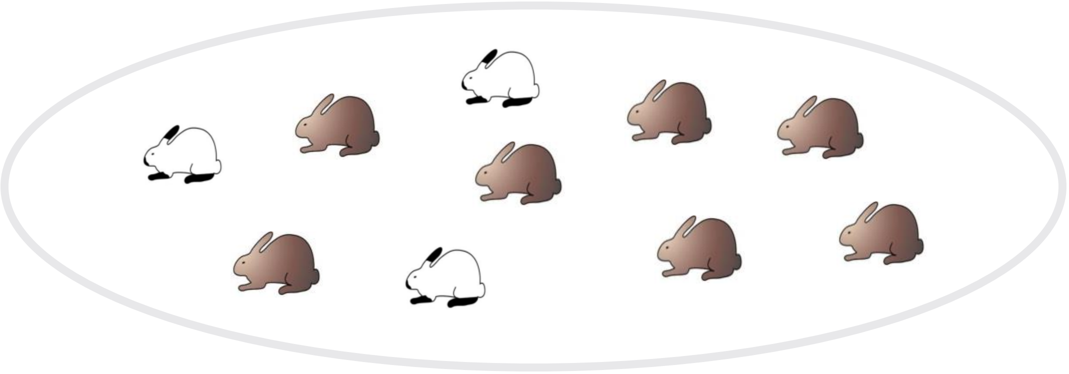
SELECTION

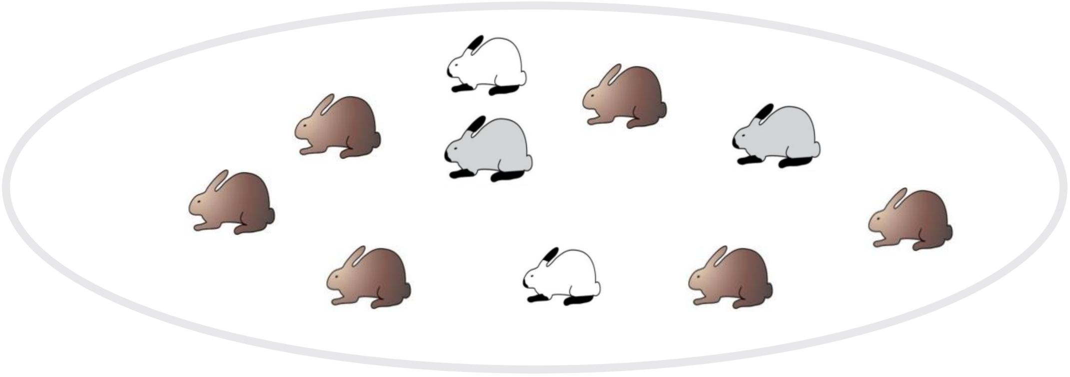


MUTATION



 $c^{+}c^{h} \rightarrow (c^{+} \rightarrow c^{ch}) \rightarrow c^{ch}c^{h}$ 

 $c^{h}c^{h} \rightarrow (c^{h} \rightarrow c^{ch}) \rightarrow c^{ch}c^{h}$ 



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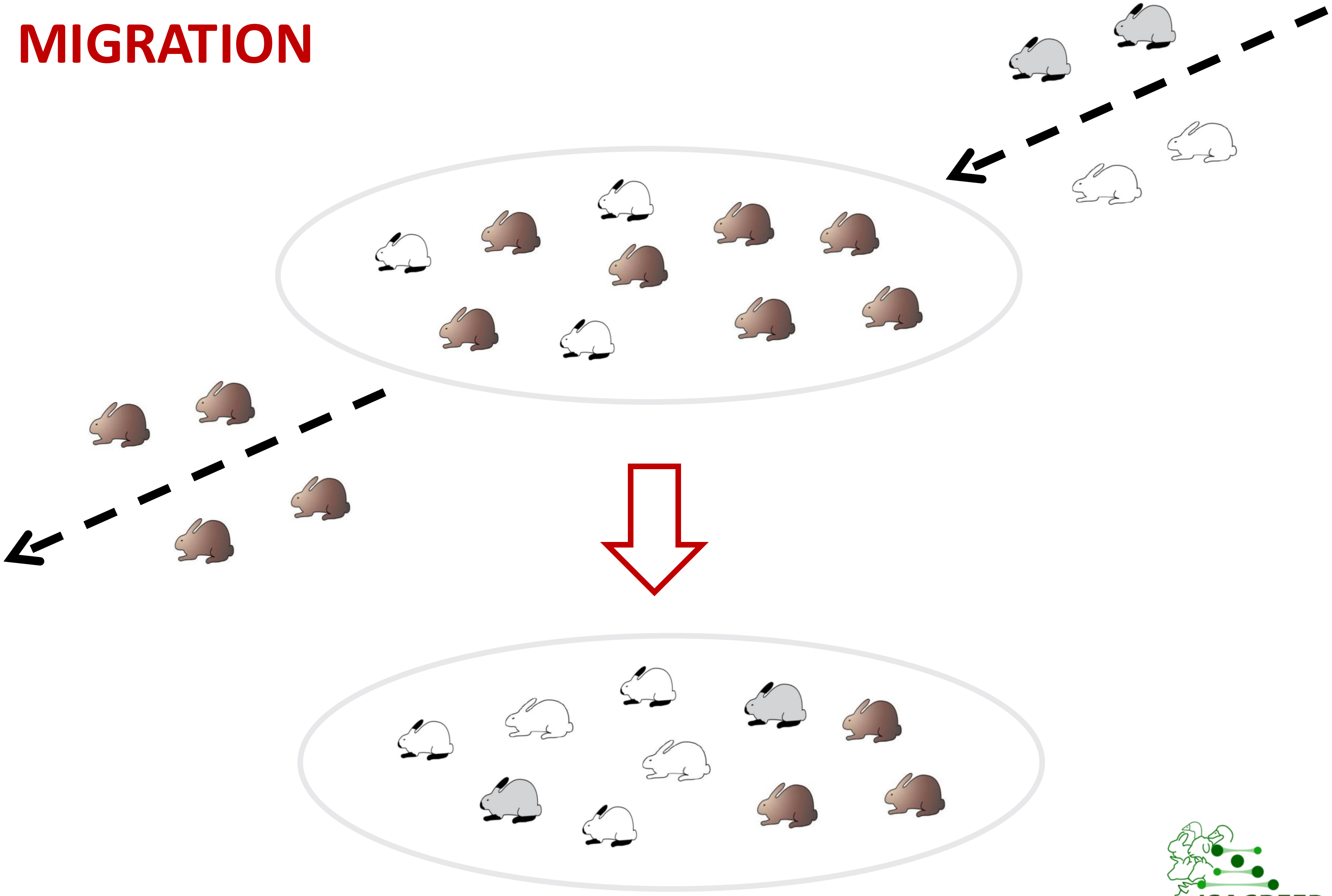
MIGRATION



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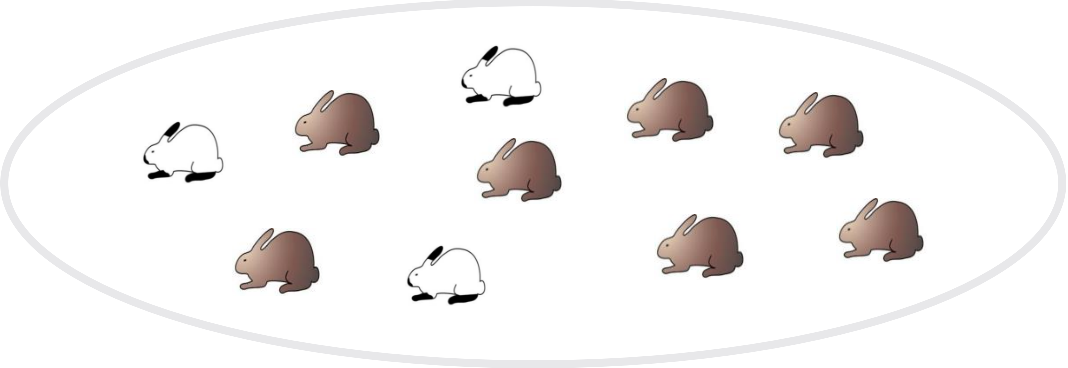
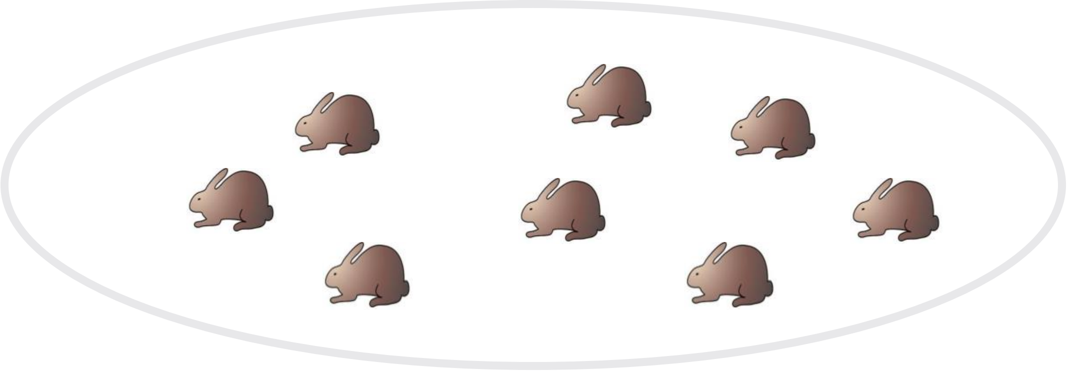
RANDOM MAITING



c^+c^h x c^+c^+

c^hc^h x c^+c^+

ONLY THEN



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WITHOUT GENETIC DRIFT (infinite population size)

 c^+c^h x  c^+c^h →

 c^+c^h

samo-oplození:
Population s N=1

$[c^+c^h]$ → $P(c+):P(c^h) = 0.5 : 0.5$

2 times → $(c^+, c^+), (c^+, c^h), (c^h, c^+), (c^h, c^h)$

1 : 2 : 1

$P(2 \text{ times } c^+ \text{ or } 2 \text{ times } c^h) = 0,5$

$P(10 \text{ times } c^+ \text{ or } 10 \text{ times } c^h) < 0,5$

$P(100 \text{ times } c^+ \text{ or } 100 \text{ times } c^h) << 0,5$

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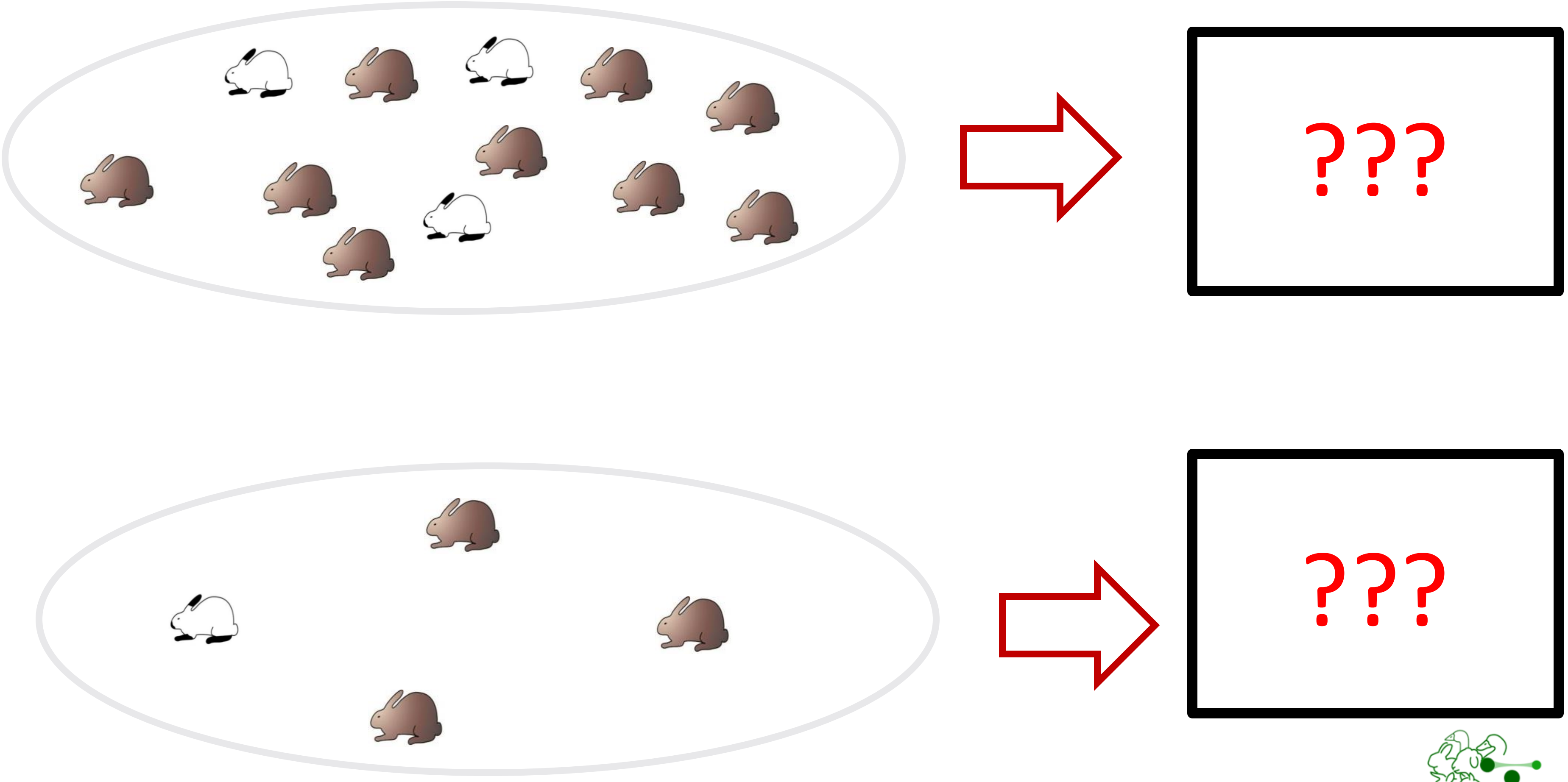
WITHOUT GENETIC DRIFT (infinite population size)



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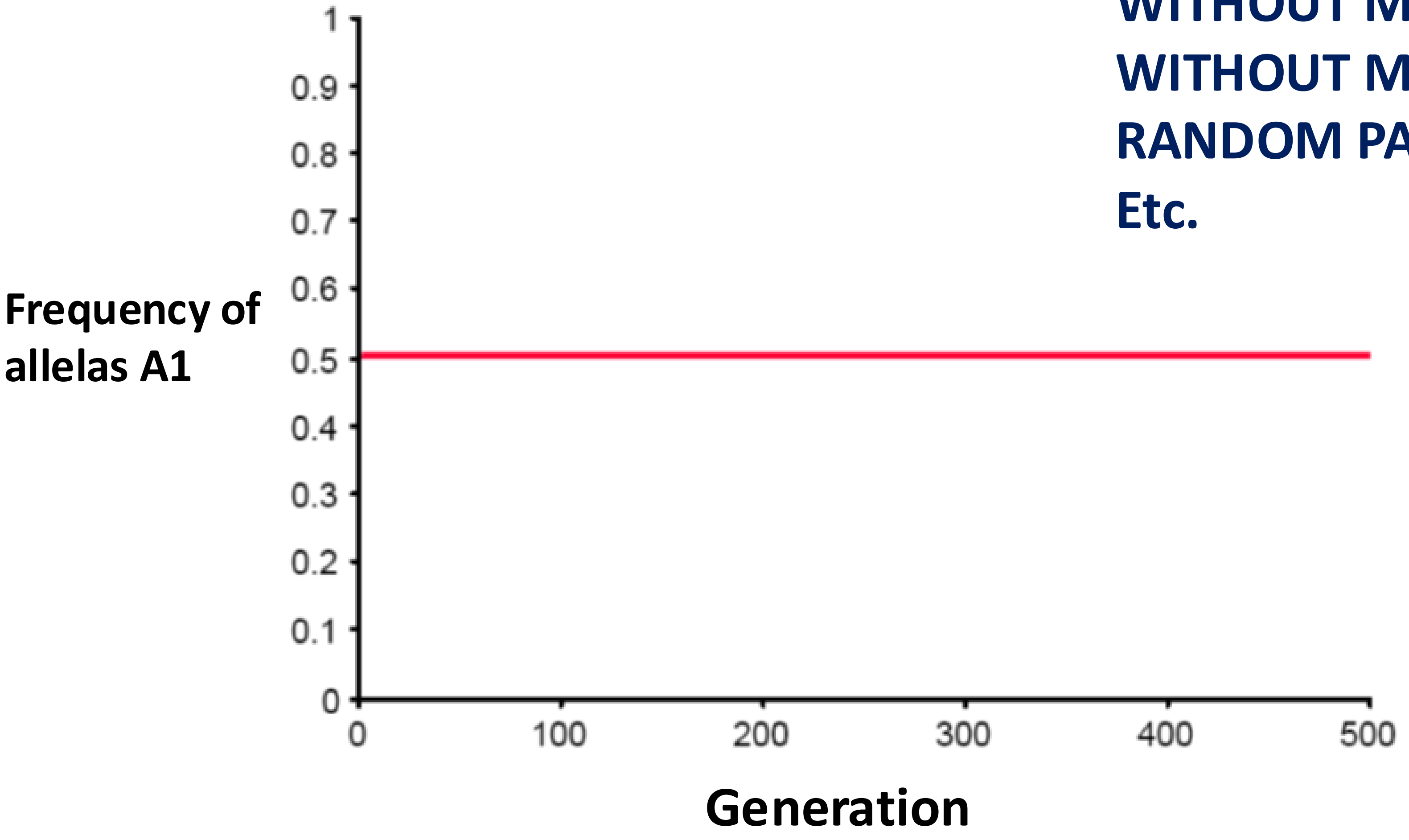
POPULATION SIZES: + infinite

WITHOUT SELECTION
WITHOUT MUTATION
WITHOUT MIGRATION
RANDOM PAIRING
Etc.



$p_0 = p_1 = p_2 = p_3 = \ldots = p_t$

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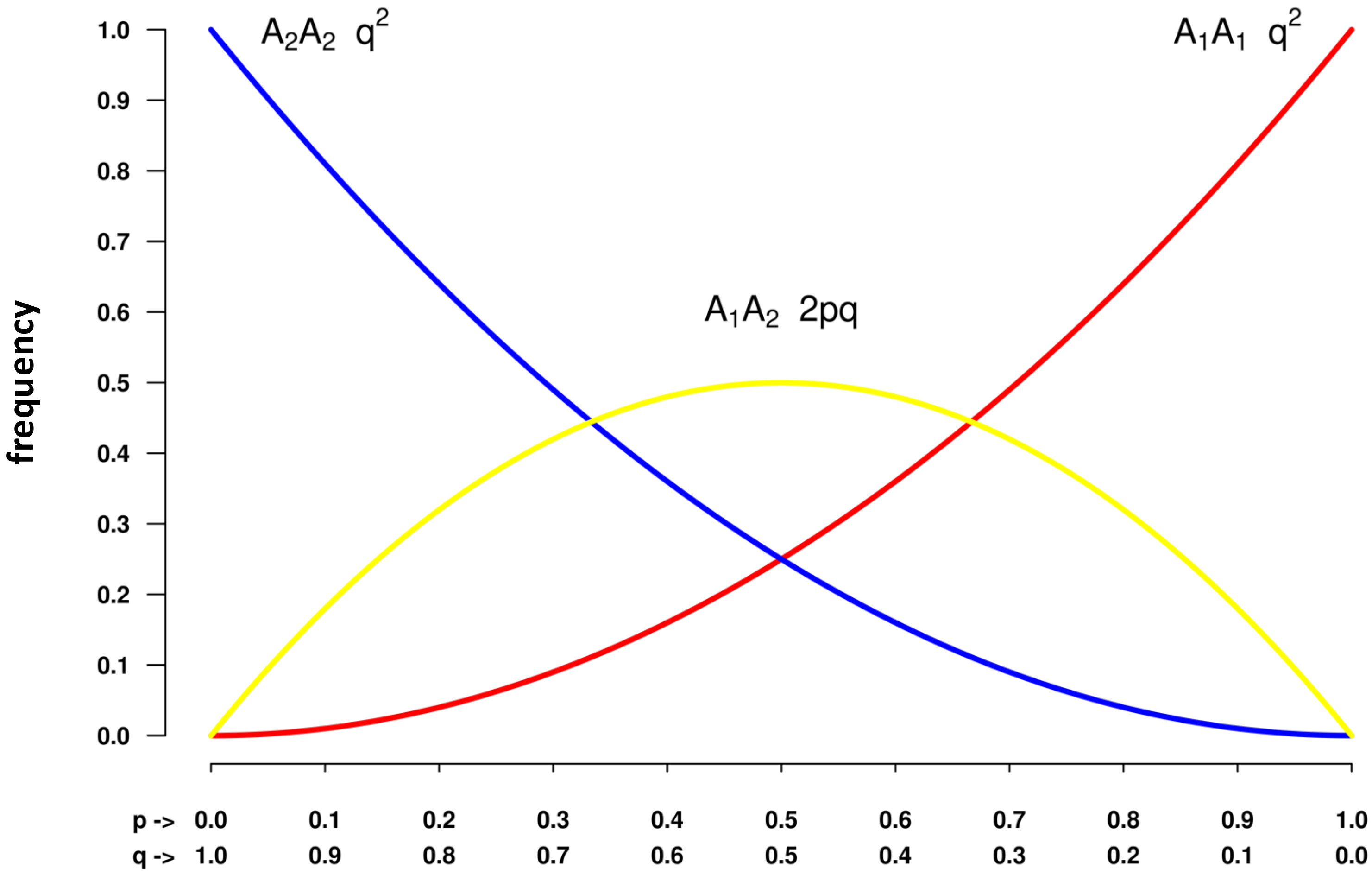
Hardy-Weinberg equilibrium (HWE)



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Thank you for your attention!

This presentation has been supported by the Erasmus+ KA2 Cooperation Partnerships grant no. ***2021-1-SK01-KA220-HED-000032068 "Innovation of the structure and content of study programs in the field of animal genetic and food resources management with the use of digitalisation - Inovácia obsahu a štruktúry študijných programov v oblasti manažmentu živočíšnych genetických a potravinových zdrojov s využitím digitalizácie"****. The European Commission support for the production of this presentation does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.*

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Picture sources

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